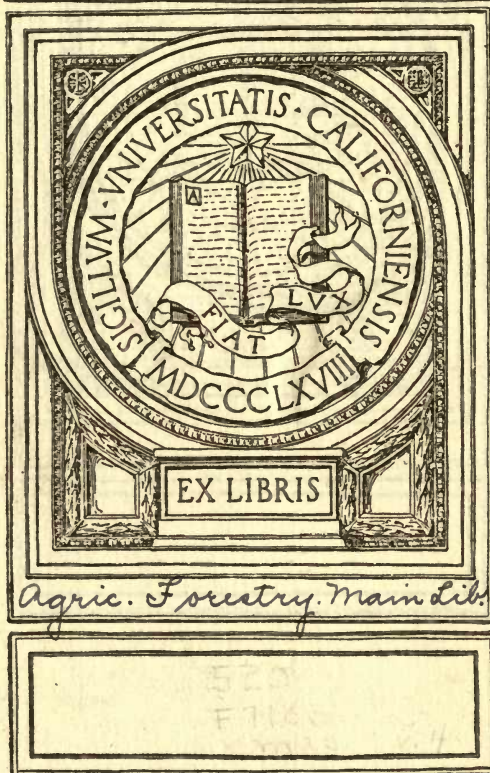


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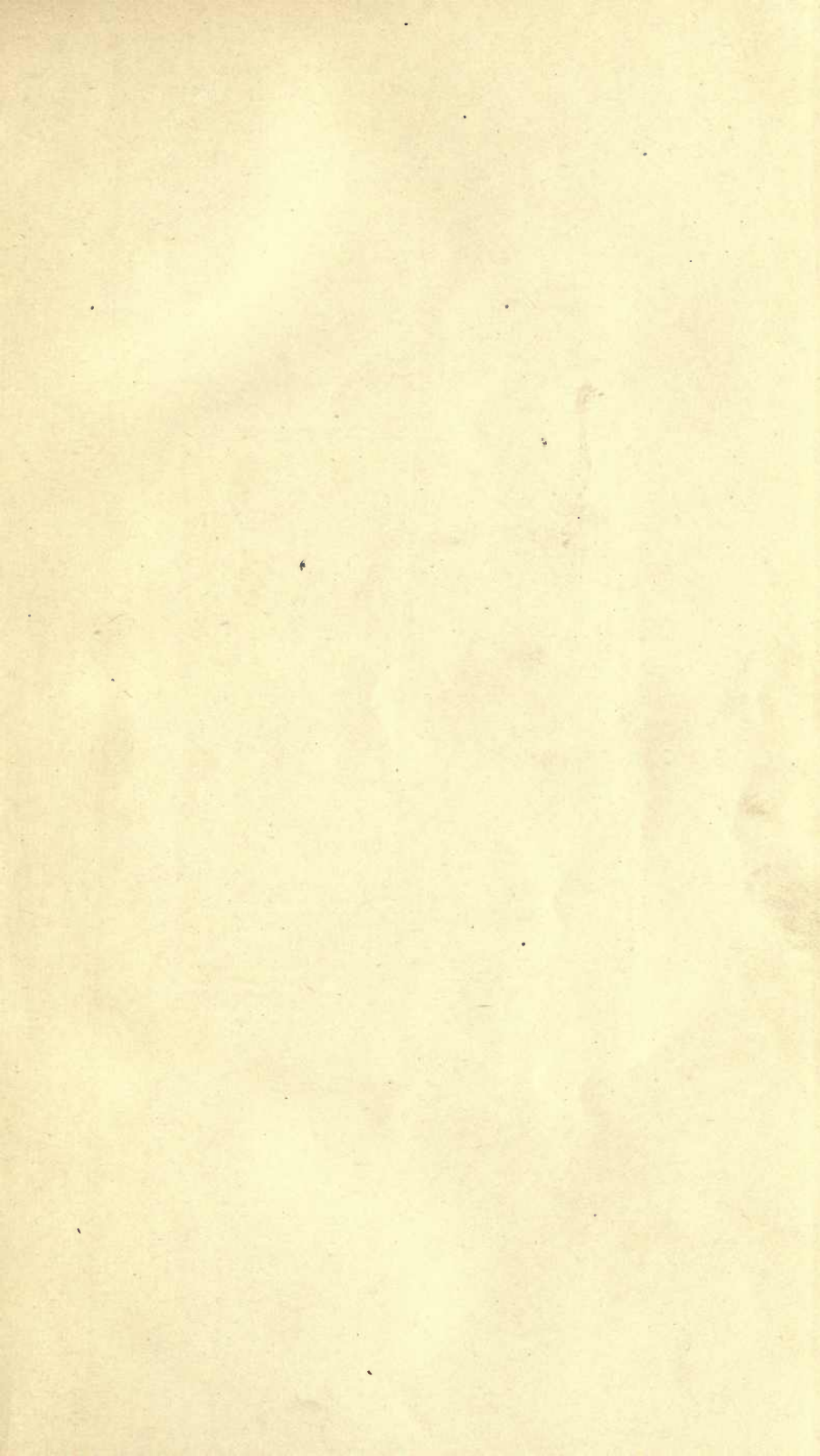


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Agric. Forestry. Main Lib.



Pamphlets on forestry in Massachusetts
"STUDY OF THE EVERGREENS"

MASSACHUSETTS FORESTRY PAMPHLETS

VOL. IV

The Evergreens. Methods of Study in Public School. By C. M. Weed under the Direction of F. W. Rane. *nc*

How to make Improvement Thinnings in Massachusetts Woodlands. By H. O. Cook. *nc*

Reforestation in Massachusetts. By R. S. Langdell. *nc*

Massachusetts Wood-Using Industries. By Hu Maxwell. *nc*

The Chestnut Bark Disease. State Forester's Office. *nc*

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MASSACHUSETTS
FORESTRY PAMPHLETS

THE *Walter Mulford*
STUDY OF THE EVERGREENS
IN THE
PUBLIC SCHOOLS.

PREPARED BY
CLARENCE M. WEED,
UNDER THE DIRECTION OF
F. W. RANE, STATE FORESTER.



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THE STATE BOARD OF PUBLICATION.

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PURPOSE.

This publication is offered by the State Forester as supplementary to "The Study of Trees in Our Primary Schools," issued by this office last year.

The coniferous or evergreen trees make an interesting group to study by themselves. They can be utilized by the teacher in the winter time, or dormant season of the year, when other material is not so accessible. In fact, at this season of the year they give great variety and beauty to the landscape. The interest in and association with the evergreens become very pronounced as soon as the deciduous tree leaves have changed from their natural beauty of summer to their grand autumnal glory, and finally fallen to the ground. The uses to which the evergreens are put at yuletide, and their part in making this season of the year one of the happiest to the child mind, make this the psychological time for their study.

If this treatise helps to awaken in our young and coming generation a greater interest and love in trees and nature it will have done its part.

Two other publications that teachers may find of assistance, if they do not possess them already, are:—

"The Commercial Forest Trees of Massachusetts. How you may know them. A Pocket Manual," for general use.

"The Study of Trees in Our Primary Schools," for teachers, mothers, and all interested in teaching children to love trees and nature.

Under the Resolves of 1908, chapter 121, the Governor and Council have designated that these publications be sold by the State Forester at a price not less than the cost thereof; and additional copies may be printed, the expense thereof to be paid from the receipt of such sales.

According to this decision the above-named publications are offered at the following prices:—

“The Commercial Forest Trees of Massachusetts. How you may know them. A Pocket Manual,” for five cents a copy at this office, or by mail for two cents extra.

“The Study of Trees in Our Primary Schools,” for twelve cents, or by mail eight cents extra.

In case a large number is wanted, as for schools, etc., they can be forwarded by express.

These publications are neatly gotten up, and as they are in great demand (the first edition of 5,000 having been exhausted in ten days), charging for them at cost is the only feasible method of dissemination.

ACKNOWLEDGMENTS.

Dr. Clarence Moores Weed, of the Lowell State Normal School, was selected to prepare this pamphlet. Owing to Professor Weed's knowledge and interest in public school work, he requires no introduction to Massachusetts teachers. In fact, the syllabus and suggestions herein given have passed the experimental stage, and have been successfully taught as outlined.

The illustrations are from prints and drawings by pupils in the Lowell Normal School and its training schools.

F. W. RANE,
State Forester.

STATE HOUSE, BOSTON, MASS.,
Oct. 1, 1908.

The ear shares with the eye the beautiful effects of weather on the landscape. The rushing of the storm through the narrow valley, the murmuring tremor of the pines in the gentle breeze, the rustling and bowing of a field of corn in an August gale, the clatter of palmettos in a wind, the rattle of pebbles on a beach, dragged down by the retiring wave, the onset of a thunder shower,—are delights for the ear as well as the eye. — CHARLES W. ELIOT.

THE CONIFEROUS EVERGREENS.

The study of the coniferous evergreens is especially desirable early in winter, and for the lower grades may well culminate at the time of the holiday festivities.

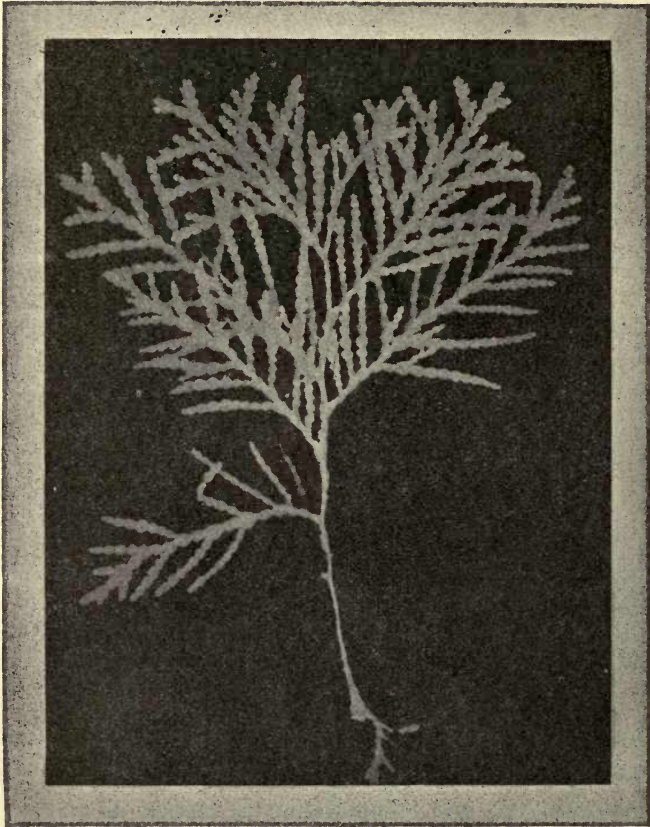
These trees furnish the most important features of many of our winter landscapes; they are of great beauty as well as of much economic value, and they give excellent opportunities for studies of distinctive educational worth. Their branches are easily obtained, and when brought into the schoolroom are of decided decorative value. They may be studied to great advantage in winter as they are available at a time when it is most difficult to get material for nature studies.

In this study of the evergreens especial emphasis should be placed upon the native species. These are to be found in fields and woods, where specimens may be gathered in abundance. A very large proportion of the conifers planted for ornamental purposes are exotic species, the determination of which is frequently difficult, and which have not the interest and associations possessed by the native sorts. An exception, however, must be made in the case of the Norway spruce, which has been so generally planted for so long a period that it is as abundant and as widely distributed as some of our native trees.

In associating the evergreens with the animal life of the winter season, the skillful teacher will point out the utility of their seeds as food for the winter birds, and the great benefit of their protection as homes, not only for the birds but for rabbits and other animals that require shelter during the winter months. The value to the trees themselves of their slender leaves in shedding snow will of course be pointed out.

In most localities it is a comparatively easy matter to get abundant material for the study of the evergreens. This is

one reason why the subject should be reserved for the winter season. Two or three small branches will furnish enough leaves of a given species to suffice for a whole class, and wherever there are large bearing trees, with little trouble one



ARBOR VITAE

can get the cones which are so necessary to an adequate study of these trees. The cones of the white pine may generally be found in abundance underneath the trees, while those of the pitch pine, though generally less numerous on the ground, are frequently within easy reach upon the lower branches. By a little searching one may often find trees which have

been blown over or cut down, so that the cones in the top-most branches may easily be reached. This applies not only to the pines but also to most of the conifers.

The cones of some of the spruces fall to the ground early, where they may readily be gathered. This is particularly true of the Norway spruce, the large and beautiful cones of which furnish most interesting objects for study. In the case of the black spruce, which abounds in peat bogs, the cones are generally within reach upon the smaller trees; this is also commonly true of the hemlock, the arbor vitæ and the tamarack or American larch. The curious berry-like fruits of the red juniper and the low juniper are also very easy to obtain.

The teacher who does not avail herself of the opportunity to make the collecting of these evergreens the object of many winter walks will miss a personal pleasure, and will not secure the enthusiasm from her pupils that she might easily get.

In the cities one can often obtain fir balsam and some of the spruces at Christmas time among the trees offered for sale as Christmas trees. It will frequently happen that such trees may be obtained directly from the pupils after the Christmas season is over.

In the hot, dry rooms of most schools the spruces, hemlock and other conifers whose leaves are shed in drying dry out rapidly and fall off, and may cause trouble for the janitors. This may be avoided to a considerable extent by keeping the specimens in unheated closets, or hanging them out of doors, when not in use; they will thus retain their leaves much longer.

METHODS OF STUDY.

The teacher who appreciates the value of visual impressions in nature study will display before the pupils twigs and cones of the pines, and such other conifers as do not drop their leaves in drying, mounted upon good-sized sheets of paper or cardboard and plainly labelled. She will also make upon the blackboard characteristic drawings of the various species studied, using as far as possible colored

crayons, showing the appearance of cones and branches, as well as detail drawings of the leaves upon a larger scale.

The evergreens may be used to great advantage in bringing the pupils into direct contact with real things in nature. The material is so easily obtained, and in such abundance, that there is no excuse for adopting the mere question and answer method in vogue in many of our schools. Give the pupils twigs, or at least bundles of leaves, and if possible cones, and let them use their discriminating powers in sorting the specimens as to species. Let them see for themselves the distinctive characters of each, and in the higher grades let them determine the species by reference to illustrated tree books. Then let them make careful drawings of the twigs or leaves and cones of each species, being sure that they know the name while they are making the drawings. Part of the drawings at least should be made with a lead pencil, securing as great a degree of accuracy as is possible, but some of them should be made with green and brown pencil crayons, by means of which very attractive pictures may be obtained. In the upper grades it may also be worth while to use water colors for some of the drawings.

The importance of blackboard drawings by the pupils, especially in the grades above the fourth, can hardly be overestimated. These are especially valuable for the memory drawing, and in the case of the evergreens, through the use of green and brown crayons, the great advantage of colors that simulate the actual plants may be utilized.

Very beautiful Van Dyke solar prints may be made of many of the evergreens. Examples are shown in the accompanying illustrations of the arbor vitæ and the white pine.

In addition to the drawings the pupils may use the same specimens for language work, which shall take the form of short essays in which the chief characteristics of the specimens are described. The length and completeness of these descriptions will of course vary with the development of the pupil, but something worth while may be done in any grade above the fourth. These written exercises should be upon paper the same size as the drawing paper. Dictation exercises may also be given, using poems and prose selections treating of the various evergreens.

For the written descriptive exercises the pupil in the intermediate and upper grades should have before him upon the blackboard some such outline as the following. The wise teacher will of course adapt it to the degree of development of her pupils, leaving out those things which the pupil will be unable to describe to advantage. If there are no cones it may be better to omit that topic.

Outline for Description of a Conifer.

1. Leaf:—	4. Fruit:—
Arrangement.	Color.
Color.	Size.
Length.	Shape.
Shape.	Scales.
Apex.	Seed.
2. Bark:—	5. Tree:—
Color.	Manner of growth.
Surface.	Range.
3. Buds:—	
Color.	
Shape.	
Surface.	

Many of the conifers have distinctive odors, which may well be noted in their study. The aromatic perfume of the arbor vitæ is very different from the resinous odor of many of the pines, and would serve to identify it at any time.

Upon the foundation laid by the studies thus outlined a more complete superstructure may be built by a study of the trees out of doors, beginning with such as may be seen from the windows of the schoolroom, and continuing as far as possible by means of outdoor excursions. Occasional reviews with actual specimens, and memory drawings of leaves and cones, as well as sketches of the growing trees, will be helpful in making permanent the pupils' knowledge of the ever-greens.

The final visible result of the pupils' work may be a booklet, into which is bound the drawings, the mounted specimens, the descriptions and the written selections. The completeness of these booklets and the perfection of their work will depend, of course, upon the development of the pupil and the kind of supervision given. To some extent such booklets

may be made in every grade of the lower schools, and they certainly may be made to great advantage in the high and normal schools. Some standard size of drawing paper, which is of good shape for artistic results, should be selected. A good size is six by nine inches, as this enables one to put both the mounted specimen and the drawing upon the same sheet if desired. To accompany the drawing paper there should be sheets of writing paper of the same size, ruled or unruled, as the development of the pupils may necessitate. All the sheets are to be punched upon the left-hand six-inch margin, so that they may be bound in covers of stiffer paper, either by the ordinary brass fasteners or preferably by means of raffia. In the latter case it is desirable that three holes be punched in the margin.

EXAMINATIONS.

It is very easy to determine whether the pupils know the evergreens they have been studying or not. Place a small branch and cone of each variety upon a side table, numbering each species, and let the pupil, absolutely without assistance, make a list of the names of the evergreens represented. Memory drawings may also be utilized for examinations, or the pupils may be required to write a synopsis of the distinctive characteristics of a certain number of species.

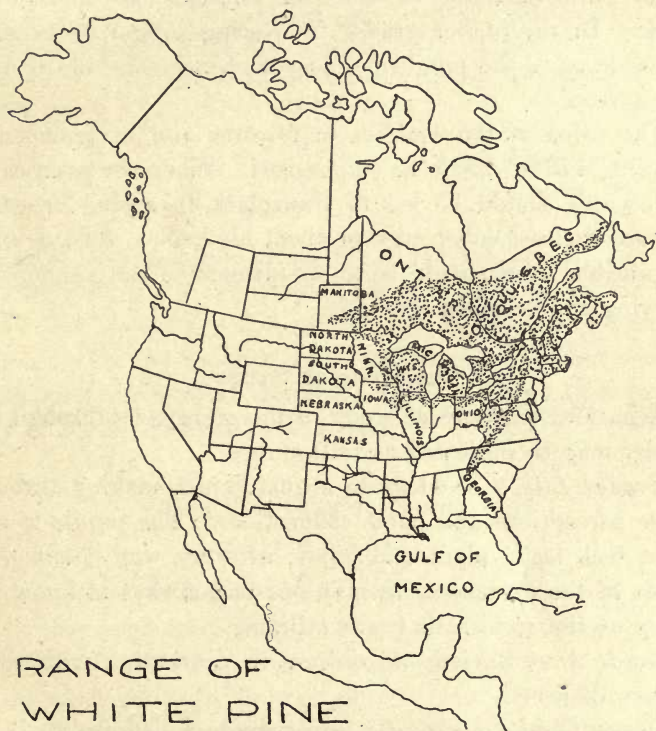
CORRELATIONS.

It may be worth while, at the risk of some repetition, to indicate briefly the correlations with other studies which may properly be carried on in connection with the study of the evergreens.

In language it is obvious that any written or oral exercise describing the evergreens is simply one phase of English expression, and may very well be utilized as work in composition. It is also readily seen that the pupil who secures, through the study of the evergreens, adequate mental images of the characteristics of the different species, and of the appearance of the trees, either singly or in forest groups, is preparing himself to appreciate references to these trees in literature. This appreciation will be increased through the

use of selections from the best writers of prose and poetry, as recommended on a previous page.

The correlation with drawing is so evident that it need scarcely be dwelt upon. No nature study is at all adequate which does not constantly afford the child opportunity to express, through graphic representation, what he sees. In the case of the coniferous trees it is especially desirable that the appearance of the tree as a whole be represented from the



point of view of the art supervisor, and that the cover designs for the booklets be made according to his suggestions. It is desirable, also, that some of the selections be from those artists who have written appreciatively of the outer world.

It is easy to see the lines which should be followed in correlating the study of the evergreens with geography. The range maps will form the foundation for this. The use which is made of these trees for commercial purposes, as lumber, as the basis for wood pulp, as the source of turpen-

tine, pine tar, Canada balsam and similar products indicates that in treating of the product the source from which it comes should receive adequate consideration. The importance of the great coniferous forests as features of the landscape and as modifiers of climate are facts of great geographic interest. The natural distribution of our various native species may also serve as a basis for interesting studies in geography.

In the lower grades the bundles of needles of the pines could advantageously be used for combinations in number work. In the higher grades interesting computations may be made as to the number of leaves on a given branch or a given tree.

The value of the conifers in forestry and in ornamental planting will of course be emphasized. Wherever practicable each pupil should be led to transplant in spring or early autumn at least one evergreen about his home. Just as soon as possible there should be an assortment of native conifers growing on the school grounds.

SEQUENCE OF STUDY.

A natural sequence of study of the evergreens through the grades may be indicated as follows:—

Grades 1 to 3.—Definite acquaintance, making through sense perceptions and name connections. The pupils to see, hear, feel, taste, plant and enjoy, in every way possible, as many of the evergreens as may be; and always to know the name of the species they are utilizing.

Grade 4.—Review of conifers in connection with topic of seed dispersal.

Upper Grades.—In one upper grade a definite study of the families of conifers, with individual booklets, including the native species. In other grades correlations with geography, language and drawing.

LISTS FOR THE LOWER GRADES.

In making out the following list the species most easily recognized are placed first, although in many localities the sequence might well be modified to meet local conditions. The sequence is of comparatively little importance, however,

provided there is a definite list for each grade, so that when the pupils enter the fourth grade they will not have been studying a few of the abundant species to the exclusion of the others. Constant reviews, of course, are necessary, but when the pupils really know a species a new one should be taken up.

<i>First Grade.</i>	<i>Second Grade.</i>	<i>Third Grade.</i>
1. White pine.	6. Red pine.	11. Juniper.
2. Pitch pine.	7. Fir balsam.	12. Red cedar.
3. Norway spruce.	8. Low juniper.	13. Yew.
4. Arbor vitæ.	9. Black spruce.	14. Red spruce;
5. Hemlock.	10. American larch. ¹	white spruce.
		15. Cypress.
		16. Southern white
		cedar.

A good time to begin the study of the conifers in any of the grades is late in November, four or five weeks before the holiday vacation. The subject can be gone over pretty thoroughly before the term ends, and rapidly finished when the winter term begins. It may well be followed then by a study of the broad-leaved evergreens.

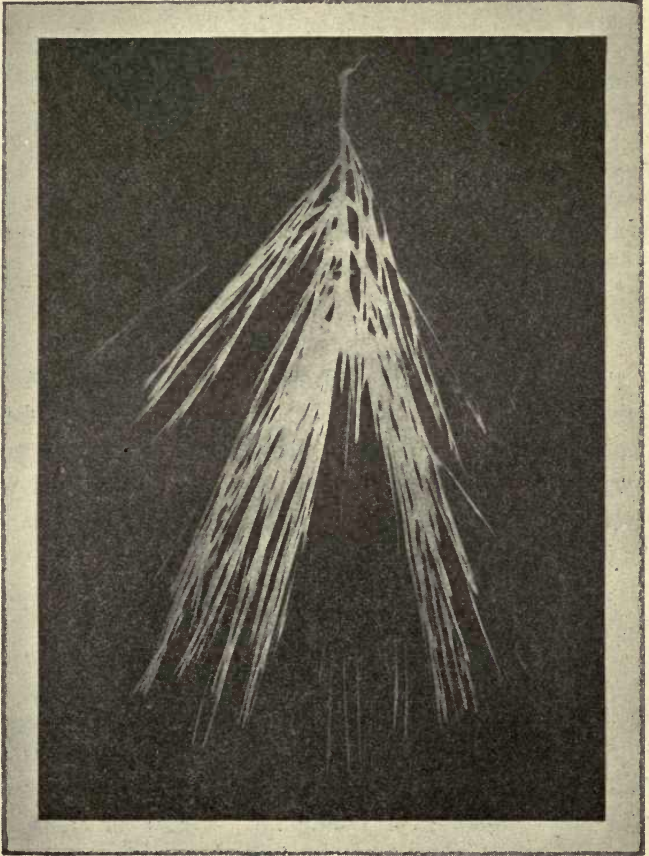
THE CONIFERS TO STUDY.

First Year List.

White Pine (Pinus Strobus). — Leaves arranged in clusters of five, each leaf being long and slender and averaging from $2\frac{1}{2}$ to 4 inches in length; its margins are finely serrate, and in cross-section it is triangular. Green in color, with two or three distinct whitish lines on the two lower surfaces. Bark of young twigs olive brown, covered with a brownish pubescence; bark of older twigs smooth and shining. Scars where the bundles of leaves have fallen off broadly oval, sometimes nearly circular. Buds conical, with a distinctly pointed tip; they are rather small, averaging $\frac{1}{4}$ inch in length. Cones large, slender, 4 ~~feet~~^{inches} to 6 ~~feet~~^{inches} long; scales resinous, whitish brown, each scale distinctly pointed; rather

¹ While the larch is not an evergreen it is a conifer and is usually associated with evergreens.

thin at the tip, with their apical margins rounded and smooth. Seed with wing. 9 inches long, light brown in color. One of our most important commercial trees, which is being planted in great numbers in Massachusetts for lumber purposes.



WHITE PINE.

Pitch Pine (Pinus rigida). — Leaves arranged in clusters of three, each leaf being long, rather stout and roughened by a row of serrations along three of the margins, the teeth pointing toward the tip. Green, with narrow rows of white spots on all the sides. Bark of young shoots yellow brown, not pubescent; its general appearance rough on account of

the scales, from in front of which the bundles of leaves come out. Bark of older branches duller yellow brown. Terminal buds very resinous, rather long, cylindrical with a conical tip, averaging $\frac{3}{8}$ inch in length; usually two or three or more smaller accessory buds beside the main terminal bud. Cones large, broad, 2 ^{inches} ~~feet~~ long. Scales thickened at the tip, with a stout sharp spine at the middle of the outer margin; borne on the sides of the branches, often in small clusters. Seed with wing .6 inches long; wings very delicate in texture, whitish, with stripes of brown. Called also torch pine.

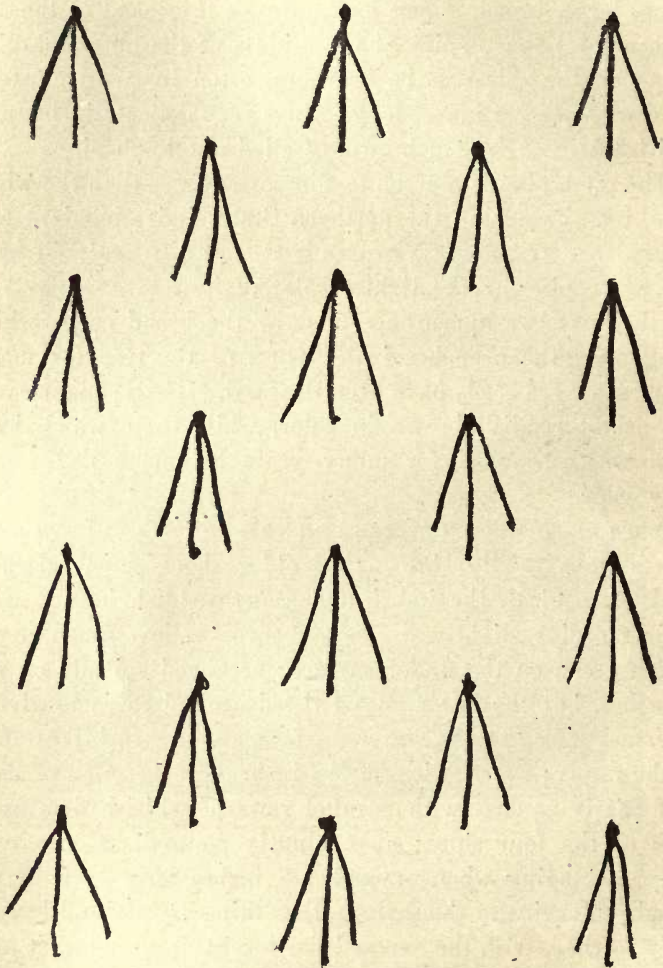
The pitch pine is a much less important tree than the white pine, but throughout the northern States it is abundant and generally distributed. The tree is at once distinguished from the white pine by the lighter color of its leaves, as well as by their coarser appearance, and by the broad cones which hang upon the branches in all parts of the tree for many years after the seeds have been dropped. The younger cones are bright reddish brown in color, while those which have been weather-beaten for many years become a dark slaty gray color.

Norway Spruce (Picea excelsa).—Bark of season's shoots light reddish brown; of older shoots much darker. Buds subconical, the imbricated scales reddish brown, with their margins slightly darker. Leaves yellow green, more bluish green on the under surface; arranged spirally on the branches, but the lower ones twisted around so as to give a flattened effect to the lower surface and a brushlike effect to the upper; average length, $\frac{1}{2}$ inch. Cross-section of each leaf nearly square, with parallel rows of whitish dots upon each of the four sides; apex bluntly pointed. Cones very large, averaging when expanded 5 inches long by 2 inches broad. Margins of the scales rather thin, slightly and irregularly toothed, with the exposed portion having somewhat of a triangular effect, though the point of the triangle is generally truncate. Winged seeds light reddish brown in color, $\frac{1}{3}$ inch long by $\frac{1}{6}$ inch broad.

The Norway spruce is, perhaps, the most generally planted for ornamental purposes of all the evergreens. Although not a native species it is so universally distributed and its

cones are so characteristic that it probably will need to be included in any study of the evergreens.

Arbor Vitæ (*Thuja occidentalis*). — Easily recognized among all the evergreens by the flattened, frond-like character



DESIGN OF PITCH PINE NEEDLES. FIRST GRADE.

of the foliage, the leaves being very small and suggestive of closely appressed, imbricated scales. Bark of older parts of the twigs somewhat shining, grayish brown. Cones small, ovoid, .5 inches long, with few obtuse scales, chestnut brown

in color. Seeds elongate oval, broadly winged on both sides. Fully developed tree generally of conical form. Foliage with a distinct, characteristic, aromatic odor, which probably arises chiefly in the little glands upon the leaves.



CRAYON DRAWINGS OF PINE TREES. FIRST GRADE.

The arbor vitæ is one of the most generally distributed of the evergreens. It is a native of the northern States, and is probably more widely planted for hedges in private grounds and public parks than any other conifer. The Indians used to call the plant by the characteristic name of featherleaf.

Some confusion is likely to arise because in many regions this species is called the white cedar, but it is very distinct from the true white cedar, or, as the latter is sometimes called, the southern white cedar. When growing in the open the arbor vitæ assumes the form of an attractive pyramidal tree.

Hemlock (Tsuga Canadensis). — Branches generally horizontal and having a flattened appearance, due in part to the horizontal position of the leaves, which are commonly two ranked on each side. There is also a row of leaves along the upper side of the twig, each leaf parallel with the twig, and in typical cases lying nearly flat upon it. In these cases the apex of the leaf points to the apex of the twig, so that the normal lower surface of the leaf becomes here the upper surface; these leaves are generally less than half the length of those that project sideways. The ordinary leaves generally a little less than $\frac{1}{2}$ inch long and not quite $\frac{1}{12}$ inch wide, each leaf having a short petiole and generally a rounded tip; the upper surface bright, shining green, the under surface appearing very much lighter, due largely to the whitish stripes along the midrib and along each side of it. Crushed leaves have a distinctly resinous odor. Youngest twigs pubescent, light grayish brown in color; older twigs much darker and roughened by the scales from which the leaves have fallen. The leaves fall off in drying.

The hemlock is one of the best known and most characteristic of the evergreens. It is widely distributed throughout the United States and Canada, sometimes becoming a forest tree more than 100 feet high. The lower branches are apt to be scraggly, so that it is not so commonly planted in open ground as some of the other evergreens.

Second Year List.

Red Pine (Pinus resinosa). — The red pine is at once distinguished from the other native pines of the northern States by its long leaves, arranged in pairs in a rather long sheath, and its cones, borne at or near the ends of the branches. The slender leaves are 4 to 6 inches long, and the sheaths are from $\frac{1}{2}$ inch to 1 inch in length. The cones are only about 2 inches long, nearly egg shaped, and the scales are smooth.

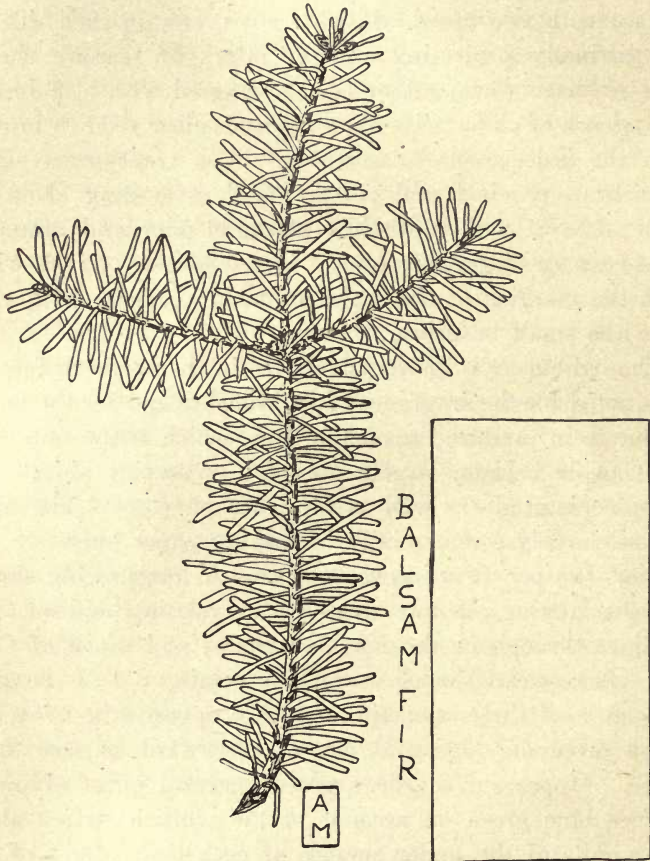
Balsam Fir (Abies balsamea). — General aspect of leafy horizontal branches flattened, due to the approximately horizontal position of the leaves. Upper surface a bright, clear green, under surface markedly bluish green. Each leaf sessile, averaging $\frac{3}{4}$ inch in length, with the sides nearly parallel and the apex distinctly notched; upper surface bright, deep green, with a longitudinal depression in the middle; lower surface with two broad whitish stripes, one on each side of the distinctly projecting midrib. Bark of season's shoots light reddish brown, rather thickly covered with stiff brown hairs; bark of older twigs darker. Buds clear reddish brown, with the imbricated scales covered by a transparent shiny varnish; subconical and rather small, averaging about $\frac{1}{6}$ inch. Leaves with a distinct balsamic odor and aromatic taste. Cones large, averaging 4 inches long by 1 inch wide, with the margins of the scales rounded; projecting upward from the small branches.

The balsam fir is an abundant tree in the northern forests. It is noted for the fragrance of its branches and for the transparent resin produced upon the bark, which is the source of the Canada balsam, largely used for preserving objects for microscopic study as well as for other purposes. The wood is used largely commercially in making paper pulp.

Low Juniper (Juniperus nana). — A low-growing shrub, often occupying circular areas in dry pastures and on open hillsides throughout the northern States and much of Canada. Leaves awl shaped, commonly coming out of the stem in whorls of three, sometimes simply opposite in two; hollowed on under side and curved downward as seen from above. Upper surface deep green; general effect of under surface blue green on account of the whitish stripes along the middle of the under surface of each leaf. Bark of the last season's twigs very light brown, with a greenish or grayish tint; bark of the next to the last season's growth reddish brown, and of older branches dark brown. Leaves .5 inches to .6 inches long. Fruit a berry-like object, $\frac{1}{4}$ inch long by $\frac{1}{8}$ inch broad; blue, with a glaucous bloom. The berry is formed by the union of the thickened fleshy scales, the tips of which may generally be seen. These enclose the three

nutlike seeds, which are curiously margined and sweetish aromatic in taste. When crushed the fruits have a distinctive aromatic odor. Called also ground cedar and ground hemlock.

Black Spruce (Picea mariana). — Bark of young branches reddish brown with a short pubescence, the hairs being brown-



ish or whitish. Leaves encircling the young twig yellow green or green in color; average length 4 inches; cross-section obtusely four angled; longitudinal lines of whitish spots generally to be found on each of the four sides; apex acute. Twigs straight or slightly curved, and commonly coming out of the main trunk nearly horizontally. Buds commonly arranged in groups of three at the ends of the more vigorous

twigs. Scales reddish brown, lower ones with long points at the tip, upper ones with thin margins; general shape ovate. Bark of older branches commonly blackish, giving a generally dark appearance to the tree, which grows especially in peat bogs from the far north southward to Michigan and New Jersey. Cone .9 inches to $1\frac{1}{2}$ ^{inches} ~~feet~~ long, oval in outline, each scale having along the outer margin numerous irregular teeth; remaining on the twigs for several seasons.

The black spruce grows abundantly in the so-called spruce bogs of the northern States. It is not a very good tree for ornamental purposes, as even in its favorite localities it is commonly unsymmetrical. It is often brought into the market as a Christmas tree.

American Larch (*Larix laricina*). — In early winter the twigs are commonly bare, having dropped the leaves late in autumn. Bark of season's shoots light reddish brown, with more or less of a glaucous bloom. Buds on these shoots globose, dark reddish brown, shining, the imbricated scales having thin margins. On older twigs the bark is darker, commonly being slaty gray in color, and the buds are on the tips of very short branches.

The American larch or tamarack is one of the most abundant cone-bearing trees to be found in the swamps of the northern States. It is a distinctive tree that seems to require an abundance of moisture. In the summer its numerous fine leaves give it an attractive appearance, which is largely lost when the leaves drop off late in autumn.

Third Year List.

Common Juniper (*Juniperus communis*). — Distinguished from the low juniper by its tree-like form, with slender and rather straight leaves. It is a northern species, which extends southward to Michigan and New Jersey. By many botanists it is considered the same as the low juniper.

White Cedar (*Chamæcyparis thyoides*). — Bark of smaller twigs reddish brown, somewhat shining, with the ends more or less greenish. Leaf buds rather small, without scales. Leaves minute, scale-like, opposite and four ranked, covering the twig; tips sharply pointed. Most of the leaves have a

rounded greenish gland on the middle of the back. Fruit a curious cone, usually rather small, seldom more than $\frac{1}{2}$ inch in diameter, with the scales opening on the inside and several minute winged seeds under each scale. Color of cone dull brownish purple. Called also cedar.

The white cedar is generally found along the eastern coast of the United States, although inland it occasionally occurs in deep swamps, where it often forms the principal tree growth. It is sometimes confused with the arbor vitæ, largely because the latter is also called white cedar. It is easily distinguished from the arbor vitæ by its curious brownish purple, more or less globular cones. The trees sometimes reach a height of 50 feet, and the wood is famous for its durable quality. Logs have been taken out of peat bogs and found to be in good condition to work into lumber.

Red Spruce (Picea rubens). — Leaves rather short, generally less than $\frac{1}{2}$ inch long, obtusely pointed, dark green, with longitudinal rows of white dots showing through a lens. Surface of last season's twigs deep brownish red, with the distinct sterigmata which make up this surface covered quite densely with stout, prominent, brownish or blackish hairs, and with the projections that serve as the bases of the leaves unusually prominent. Bark of earlier years' growth darker, especially on the sides most exposed to the weather. Buds rather prominent, reddish brown or brownish red in color, darker at the obtusely pointed apex. Surface of buds hairy. Cones deep reddish brown in color, quite regular in size and shape, when fully opened averaging $1\frac{1}{2}$ inches long by 1 inch wide. Scales with the margin slightly irregular, giving a suggestion of short, obscure teeth. Seed with its wing $\frac{1}{3}$ inch long, the wing at its broadest part being half that width. General outline broadly triangular, with the light grayish brown wing terminal on the dark brown seed.

White Spruce (Picea Canadensis). — Bark of season's shoots light brown, with bases of leaves of a slightly reddish brown tinge; bark of older branches very much darker. Buds subconical; scales reddish brown, imbricated. Leaves bluish green, a little lighter when seen from below; those on the under part of the twig twisted around so as to give the upper

surface of the branch a much more dense appearance than the lower surface. Average length of the leaf $\frac{4}{5}$ inch; four angled, sharply pointed at tip, with stripes of white dots on each of the four sides. The bruised leaves have a pungent, aromatic, slightly disagreeable odor. Cones generally termi-



BLACK SPRUCE

nal on the smaller twigs, when fully developed averaging $1\frac{1}{2}$ inches long by $\frac{3}{4}$ inch broad, generally ovate cylindrical when opened. Scales with thin and more or less rounded margins, the middle of the margin being commonly truncate and generally entire. Seeds rather small; length with wing being but $\frac{1}{4}$ inch; width of wing $\frac{1}{6}$ inch.

The white spruce is one of the most beautiful of our native evergreens, forming a tall pyramidal tree, with the branches extending from the ground. The cones drop off soon after fruiting, so that they may be found beneath the tree at any time. The blossoms appear during April and May.

Red Cedar (Juniperus Virginiana). — The twigs of this common evergreen are especially interesting because of their two forms of leaves. In one form the leaves are small and scale-like, arranged in opposite pairs which alternate with each other, each leaf being acutely pointed and subtriangular in its shape. The other form of leaf is long and slenderly lanceolate or needle-shaped, with a very sharp point. This second form of leaf seems in general to be present upon the twigs and branches which have grown rapidly. The bark of the older parts of the branch is reddish brown and shining. The fruit is a bluish, berry-like object, the size of a pea, in which the thickened outer scales have grown together to enclose the three or four angular seeds. Called also savin.

The red cedar is an interesting and characteristic tree, scattered over almost the whole of eastern North America. It varies greatly, but in its typical form it has a characteristic columnar appearance which is very attractive. The berries form a large part of the winter food of many birds, so much so in the case of the cedar bird as to give that species its common name. The tree belongs to the genus *Juniperus* and is sometimes called the red juniper.

American Yew or Ground Hemlock (Taxus baccata). — General appearance of the leafy branches flattened in a way suggestive of the hemlock, the leaves, however, being much larger and more robust, and the color very much more of a yellow green. Average length of leaves $\frac{1}{2}$ inch to $\frac{3}{4}$ inch; width, $\frac{1}{12}$ inch. Each leaf narrowed at the base into a short petiole and sharply pointed with a mucronate apex; longitudinally convex above and concave below. Midrib projecting on both surfaces, more prominent on upper. Shining yellow green on the upper surface, less shining and lighter on lower surface. Bark of young twigs shining greenish brown; of older twigs reddish brown. Buds small, with rather thick imbricated scales. Each scale brownish green, with a whitish longitudinal stripe along the middle and sometimes upon the

margins. Fruit a curious, red, berry-like object, formed by the disk becoming pulpy and cup-shaped, so as almost to cover the hard seed; $\frac{1}{4}$ inch long. Small masses of the cut twigs have a curious musky odor, very different from that of any other of our evergreens. The leaves remain upon the twigs in drying.

SYNOPSIS OF THE CONIFERS.

The conifers as a whole are distinguished from the majority of seed-bearing plants in that the seeds are borne on the face of a scale rather than enclosed in an ovary. Our native species belong to two families, — the pine family, which includes all but one of them, and the yew family. The former is characterized by cone-like fruits, while the latter is characterized by its soft, berry-like fruit.

The Pine Family (Pinaceæ).

The Pines (Pinus). — The pines are known by having the leaves needle-shaped and in clusters of two to five, and by the numerous woody cone scales. The three following species are the most generally distributed native species: —

White Pine (Pinus Strobus). — Leaves long, five in a sheath; cone long, with margins of cone scales smooth and unarmed.

Pitch Pine (Pinus rigida). — Leaves long, three in a sheath; cone broad, with outer end of cone scale armed with a pointed tooth.

Red Pine (Pinus resinosa). — Leaves long, two in a sheath; cones not long, oval conic; margins smooth.

The Larches (Larix).

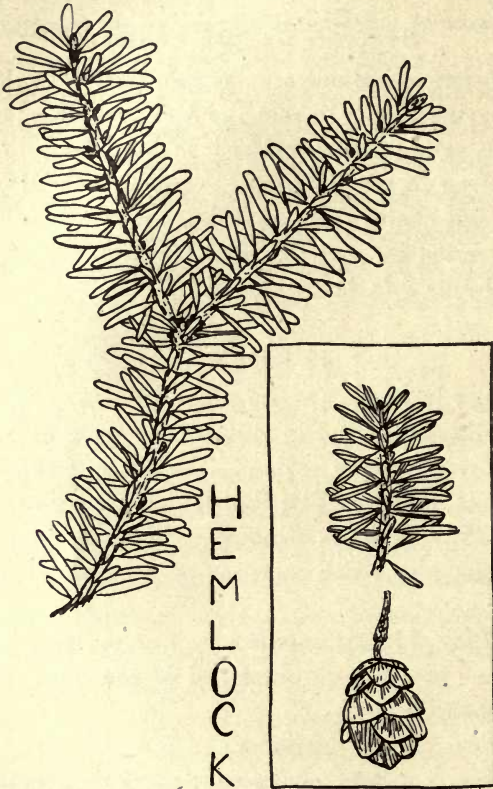
The larches are characterized by having the leaves in dense clusters on the ends of very short branches, the leaves falling off late in autumn. Our native species: —

American Larch or Tamarack (Larix laricina). — Small, short, pale green leaves, in dense clusters. Small branches, not drooping. Cones persistent and erect on twigs.

European Larch (Larix Europæa). — Distinguished by the drooping character of the branches. Commonly planted for ornament.

The Spruces (Picea).

In their general aspect the spruce trees are similar, being conical in outline and having rather short, four-sided leaves, which spread in all directions on the branches, although they



commonly project upward in a manner that gives them a brush-like effect. Leaf buds scaly and generally more or less resinous.

Norway Spruce (Picea excelsa). — Distinguished by the large cones, 4 or 5 inches long, and the drooping position of the smaller branches. An introduced species.

White Spruce (Picea Canadensis). — Distinguished by the absence of hairs upon the bark of the smaller branches; cones oblong, cylindrical.

Red Spruce (Picea rubens). — Distinguished by slender pubescent twigs, with sharply pointed leaves, and cones that fall off.

Black Spruce (Picea mariana). — Distinguished by stout pubescent twigs, with the leaves abruptly pointed, and cones that remain upon the tree.

The Hemlock (Tsuga Canadensis).

Only one species in the northern States, distinguished by flat leaves with short petioles.

The Balsam Fir (Abies balsamea).

Easily recognized by the erect cones and the rounded or notched tips of the rather large, flattened leaves.

The Bald Cypress (Taxodium distichum).

This tree has not before been mentioned in this article, as it is a southern species, ranging north to Delaware. The scales of the small cones are arranged spirally and the leaves are deciduous.

The Arbor Vitæ (Thuja occidentalis).

Easily recognized by the flattened appearance of the branches, and the small cones with opposite scales.

The Southern White Cedar (Chamæcyparis thyoides).

Known by the small, scaly leaves and the globose cones with peltate scales, each scale having a projecting tooth on the middle. Ranging as far north as Massachusetts.

The Junipers (Juniperus).

The junipers are readily known by their fleshy, berry-like fruits, which are cones modified through the thickening of the scales. The leaves vary much in size in the different species. Many leading botanists now separate the common juniper into two species, juniper and low juniper, according to its tree-like or spreading habit.

Juniper (Juniperus communis). — A tree-like shrub or

small tree, having awl-shaped leaves nearly $\frac{1}{2}$ inch long, arranged in whorls of three. Fruit a berry-like cone, dark blue, with a glaucous bloom when ripe.

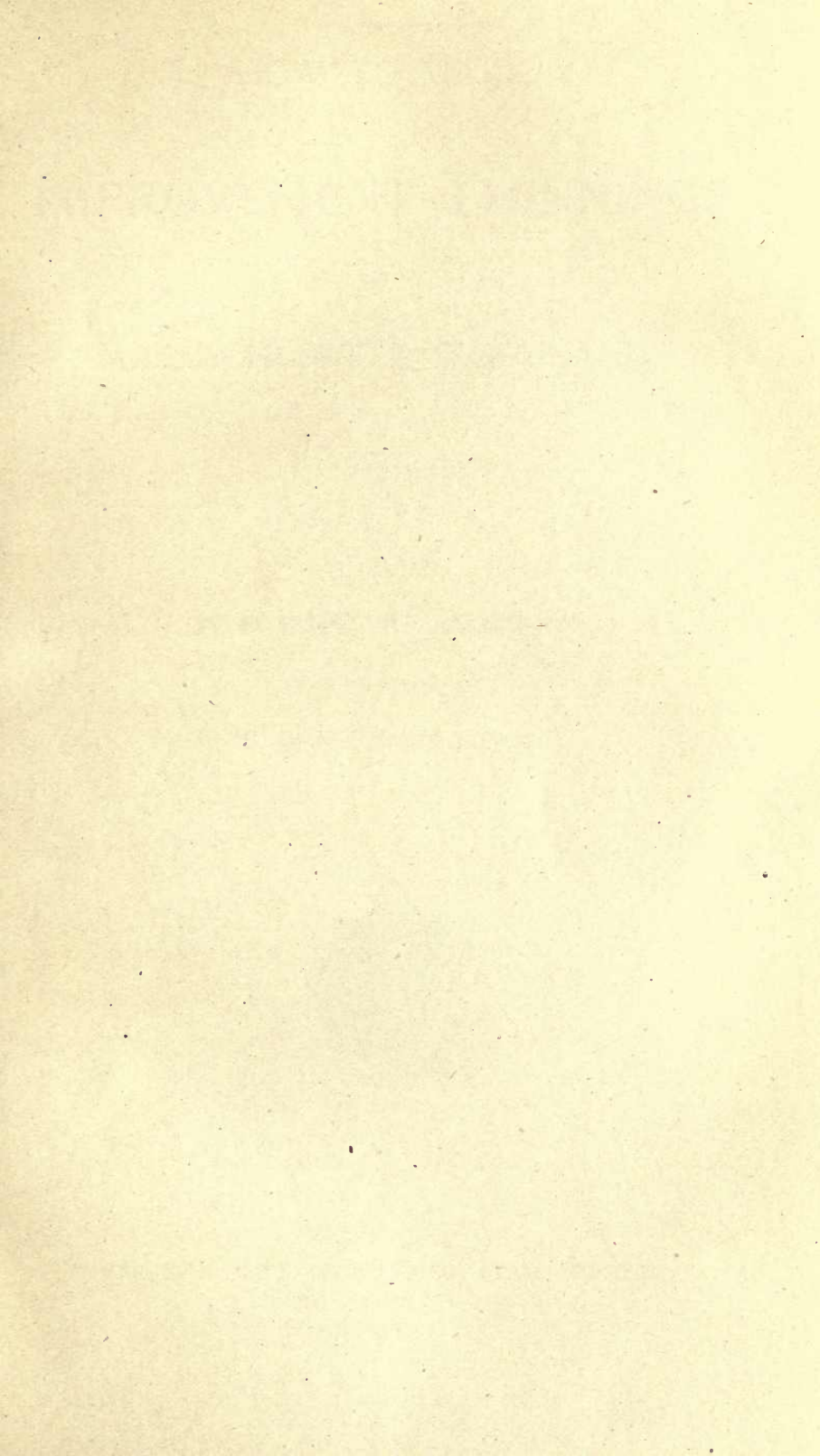
Low Juniper (Juniperus nana). — A low, spreading shrub, very abundant in rocky fields in many regions, with awl-shaped leaves arranged in whorls of three, and berry-like fruits; dark blue, with a glaucous bloom when ripe. Called also ground cedar.

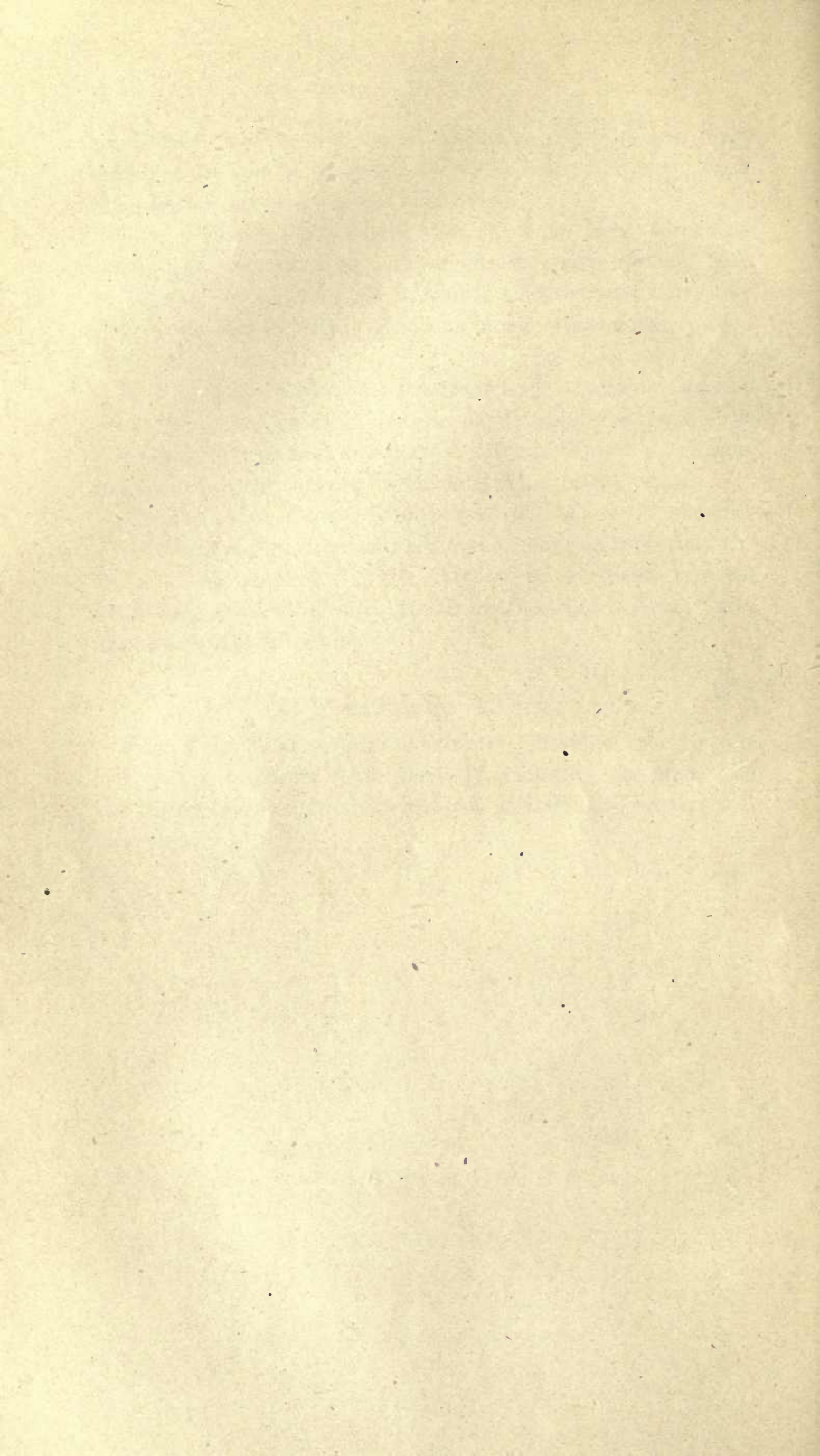
Red Cedar (Juniperus Virginiana). — A tree or tree-like shrub with two kinds of leaves, partly small and scale-like and partly longer and awl-shaped. Fruit, berry-like, similar to that of the low juniper, borne on short, straight twigs.

Shrubby Red Cedar (Juniperus Sabina). — A shrubby procumbent form, similar to the red cedar except that the fruit is on recurved twigs. Found in northern regions, extending southward only to Maine, northern New York, Minnesota and Montana.

The Yew Family (Taxaceæ).

The Yew (Taxus Canadensis). — Characterized by the red, pulpy, resinous fruit partially enclosing the seed, and the linear leaves with short petioles and awl-shaped tips. A low shrub.





HOW TO MAKE

IMPROVEMENT THINNINGS

IN

MASSACHUSETTS WOODLANDS

BY

H. O. COOK, M.F., ASSISTANT

UNDER THE DIRECTION OF

F. W. RANE, STATE FORESTER



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INTRODUCTION.

This bulletin is published by the State Forester that our people may have at their disposal the information so often desired on the thinning of woodlands.

In 1905 the Massachusetts State Forester published a small pamphlet on "Improvement Thinnings." The edition of this pamphlet has long since been exhausted.

The present treatise enlarges on the subject, and has much additional value in that it contains data and illustrations taken from actual experiments.

While it is believed that after studying this pamphlet carefully a man of good judgment should be able to go into his woodlot and select approximately at least the right trees to be thinned out, yet it must be said that the problems of thinning are many and diverse, and it is impossible to give more than the general theory in a publication like this.

Your attention is called to the policy of this office in sending out trained foresters at the request of any owners of woodland in the State. The forester will go over the land with the owner or his agent, and will explain to him his ideas on its treatment. The expense to the applicant for this advice is merely the travelling expenses of the visiting forester. Application blanks for such work can be had through your local forest warden, or by sending directly to the State Forester's Office.

ACKNOWLEDGMENTS.

The work of writing and compiling the data in this bulletin was done by my assistant, Mr. H. O. Cook, M.F., who was assisted by Mr. H. F. Gould, M.F., in the field work.

Particular attention is also called to the "Report on the Practical Thinning of a White Pine Woodlot," at the end of the bulletin. This work was accomplished under the direction of a former assistant, Mr. J. J. Dearborn, who did the work so well that the Diamond Match Company sought his services.

F. W. RANE,
State Forester.

HOW TO MAKE IMPROVEMENT THINNINGS IN MASSACHUSETTS WOODLANDS.

IMPORTANCE OF THINNING.

By improvement thinnings and cuttings we mean the systematic removal of a portion of the trees in a growing forest, in order to benefit the portion that remains. It is the forester's method of cultivation, and it is the only practical way he has of increasing the yield and improving the quality of his crop. The methods of the arboriculturist are, except in limited cases, too costly to have a place in practical forestry.

Those people who doubt the value of forestry practices often argue against thinnings, on the ground that nature's methods must be the best. It is no more true that nature's methods are best in the forest than in the orchard or garden. The practice of thinning in European forests for nearly one hundred years has established beyond a doubt that this work increases the amount and quality of the lumber. In 1830 the average annual growth in German forests was 20 cubic feet per acre, while in 1904 it was 65 cubic feet, — an increase of 300 per cent., which can be attributed almost entirely to the methodical thinning of their forests.

Nearly 45 per cent. of the land area of Massachusetts is covered with some form of woodland growth, which can be apportioned roughly among three main types: the pine forest, which has come up on abandoned fields and pastures; the mixed growth, composed of hard woods, usually of seedling origin; together with pine and hemlock and sprout forest. Above an altitude of 1,200 feet spruce replaces pine. A seedling tree is one which has come from a seed or nut; and by a sprout we mean one which had its origin in a sucker sent out by a stump from which a tree has been cut.

The principles of thinning apply to all kinds of forest, but it is perhaps the sprout land which chiefly needs improvement. It is the largest single type, and yet, with the exception of sprout chestnut, which is used for ties and poles, this sprout land is at present producing nothing but cord wood. Proper care might bring these cord wood stands to producing saw timber.

THEORY OF THINNING.

In order that one may understand the principles which underlie the process of thinning, he must know something of the physiological growth of single trees, and of that collection of trees known as a forest.

Plants are made up of tissues composed of numberless small cells. These cells are largely composed of carbon derived from the carbon dioxide of the air and water. The carbon dioxide enters into the leaves through minute pores (stomata), and by the action of the sunlight on the green chlorophyll grains, the process of assimilation, which in plants answers to digestion in animals, takes place. The carbon is combined with the water and a small amount of mineral matter taken from the soil by the roots to form the growing material of the plant, while the oxygen is returned to the air. Therefore any crowding or shading which deprives the tree of these necessary agents, foliage and sunlight, checks its volume growth in proportion.

To take a simple example, let us suppose a plantation set out with seedlings 6 by 6 feet apart; then there will be 1,210 trees on an acre, and each tree will have 36 square feet in which to spread its branches. When the side branches meet we have what is called a closed stand, and a struggle commences. It is characteristic of trees to take all the room they can get; and not having any more at the sides, they seek the sunlight by growing upwards at a rapid rate. Trees even of the same species differ in their rate of growth, so that some get ahead of the others; and when they do, they spread out their side branches and so overtop their weaker neighbors. Unless these overtopped trees happen to be in the class called by foresters tolerant, *i.e.*, shade-bearing, they will soon sicken and die. By the time our plantation is fifty years old, only 300 trees will remain of the original 1,210.

In the early life of the forest, say the first fifteen to twenty years, a sharp conflict of this kind is very useful, for it produces all tall, straight trees; in the second place, on account of the dense crowding the side branches are killed off when young, and the tree is free from knots; and in the third place, the ground is kept shaded and the moisture retained in the soil. After twenty years growth, however, these objects have been accomplished, and then the forester steps in and opens up the stand so as to allow the crowns to spread. Larger crowns mean, of course, a more rapid increase in volume growth. Furthermore, the slower-growing trees

are removed while they are still alive and fit for use, and are not allowed to gradually sicken and die, an invitation to insects and diseases of the forest.

In the case of sprout land the crowding is generally more severe and the need of thinning more urgent than the plantation supposed above, for from every stump 10 to 50 suckers may spring, so that several thousands of young trees may start up on an acre.

PRACTICE OF THINNING.

WHEN TO THIN.

The conditions which exist in most parts of this country do not permit us to thin as early or as often as is desirable. The market for small-sized wood is uncertain, and we must be satisfied with a less intensive cultivation of our forests than our European friends enjoy.

A safe rule to follow is to thin a stand as soon as the material to be removed has reached such a size that its sale will pay the cost of the removal, and as soon again as the material to be removed has accumulated in sufficient quantities to pay the expense involved. The profit is to be found in the improved growth of the stand. When the woodlot owner is a farmer, or has farm help during the winter months, when they might be idle much of the time, the net cost of the work may be held quite low.

A less commercial and a more scientific rule would state that a thinning should be made as soon as the trees have attained their maximum rate of height growth, and the lower limbs are well pruned off. In practice this would mean a moderate thinning when the stand is from twenty to thirty years old, and a heavier one ten to fifteen years later. If the rate of growth of our native trees and their response to treatment were better known, we could afford to thin at some net expense, being able to calculate what the profit would be; but unfortunately American foresters have not had time to gather the necessary data on this subject, and until we do, the rule of letting the material pay the expense is the best to follow.

WHAT TO THIN.

The extent to which a closed stand may be opened up depends on several circumstances. Species which are called "tolerant," because they stand the shade well, should be kept quite thick, for they cling tenaciously to their side limbs. Hemlock and beech are extreme examples of "tolerant" trees. A forest on a dry,

sandy soil or on a hill top should not be thinned as heavily as one on low, moist ground; because under such circumstances the soil must be kept shaded to retain the scanty supply of moisture. The age of the trees and the kind of timber desired have an influence on the decision of what to take. For instance, if the owner of a chestnut sprout stand wishes it to yield poles rather than ties or lumber, he should thin it lightly.

The simplest problem of thinning is in a woodlot consisting of but one species. We first divide the trees into four classes: dominant, intermediate, suppressed, and dead. Dominant trees have large, full crowns, well up in the light. Intermediate trees receive light from above, but are somewhat crowded at the sides, some more than others. Suppressed trees are those which have been wholly overtopped by their more vigorous neighbors, and are slowly dying. A moderate thinning would consist in the removal of the intermediate trees which are closely pressed by their neighbors, and all the suppressed trees if they will make a marketable product. Dead trees do no injury to the growing crop, and are only removed to improve the appearance of the woods, or as a precaution against fires.

When the woodlot contains a number of species the problem becomes more complicated, for we have the relative value of species as another factor which we must consider. The relative worth of different species depends in part on their value in the market; in part on the owner's plans as to the final disposition of the woodlot; and in part on their adaptability to the soil in which they are growing.

The hard woods of the eastern part of the United States are divided into two types: the northern and the southern. Generally speaking, the order of preference in the northern hard woods would be rock maple, paper birch, yellow birch and beech. Among the southern hard woods the names might be arranged as follows: chestnut, white ash, red oak, hickory, white oak and soft maple. Gray birch, poplar and wild cherry are usually classed as forest weeds, and are taken out. Where these latter three species are growing by themselves, and are not interfering with other and better trees, they can of course be left; but they are not worth any improvement work.

Where white pine is mixed with deciduous trees, it is usually favored at their expense; and spruce in the higher altitudes should be similarly benefited. Pitch pine, however, is in a class below

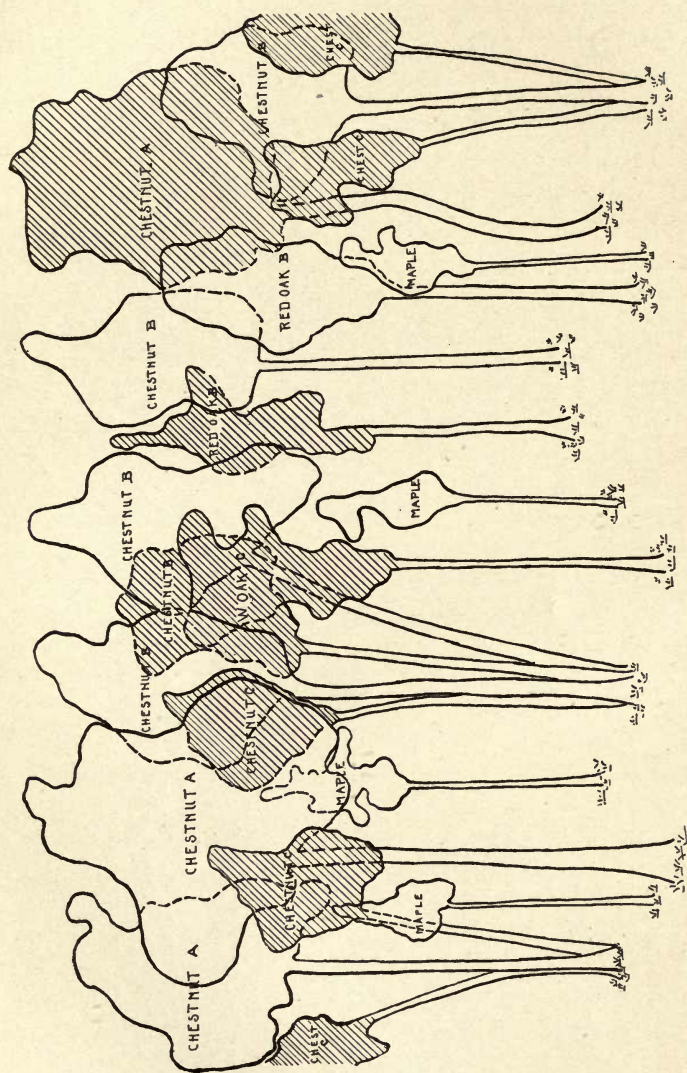


DIAGRAM NO. 1.

the better hard woods; and there is no call to favor hemlock, because it is very "tolerant."

After the trees have been classified and the order of preference by species determined upon, a third consideration must enter into our calculations. Defects, such as decayed trunks, fire scars or extreme crooks, are a sufficient reason for the removal of a tree; so that it is not impossible to have a woodlot in which the dominant trees, being in poor condition or of a valueless species, would be removed. Such a cutting could, however, scarcely be called a thinning, but would rather partake of the nature of an improvement cutting.

One can readily understand that the man who is put in charge of a thinning operation must have sound judgment, and be well instructed in the principles of the work. Where possible, it is well to have a trained forester mark the trees to be cut. It is better to be conservative rather than radical in the selecting of the trees to be removed, as a thinning which is too light can be easily remedied, but one which is too heavy will take years to mend. A mere cleaning up of the underbrush and a few suppressed trees is not a thinning, however.

In practice it is customary to blaze the trees to be cut, and often they are blazed twice, once about 4 feet from the ground, and once low down on the stump. Unless one has great confidence in his man, it is not wise to let the chopping out at so much a cord, because as a rule in a thinning operation we take only the smaller and poorer trees, so that the chopper is under a great temptation to increase his pile by taking some of those intended to be left, and it is difficult to detect the fraud.

EXPLANATION OF DIAGRAMS.

We have endeavored to represent in Diagram No. 1 a section of a typical sprout chestnut stand, 50 feet in length and 20 feet in width. The trees of the dominant class are marked A; the intermediate class, B; and the suppressed trees, D. The small maples, although apparently suppressed, are not so; but, being very tolerant of shade, they have come up under the shadow of the chestnuts, and form a sort of second cover. The trees removed in thinning include five suppressed, two intermediate and one dominant. The dominant chestnut was removed primarily because of its poor, crooked bole, and secondarily because there was a good red oak and a chestnut ready to grow into the vacated space. The maples

were not cut, because they were so small that they could not interfere with the larger trees, and they help to keep the ground shaded until the broken cover is re-established. Diagram No. 2 represents the stand as it appeared after the thinning.

Diagram No. 3 represents a group of six sprouts, originating from a single stump. They range from 4 to 8 inches in diameter, and from 45 to 55 feet in height. It is difficult to show on a flat piece of paper and by a diagrammatic drawing the sprouts as they were actually placed around the central stump; but in the space allotted by nature to the group they were overcrowded. The problem was then to reduce their number in such a way that the crowns of those that remain will utilize the limited space to the best advantage. The drawing marked "After" shows how this was done. The diagram does not indicate very well why the left-hand sprout should have been taken away, but its removal was determined by its relation to neighboring trees not shown in the picture.

RESULTS OF THINNING.

We said in the section on the "Theory of Thinning" that the more light and air a tree receives, the more rapidly it grows in diameter; so that a thinning, by opening up the stand and allowing the crowns of the remaining trees to enlarge, stimulates the volume growth of the stand. There are fewer trees in the stand, but larger and better ones. This may not be considered important until we realize how much more valuable a tree of large diameter is than a small one. For example, the average white pine, 10 inches in diameter breast high, and 60 feet in height, contains 95 feet of round-edge lumber; whereas a pine of the same height, 15 inches in diameter, contains 195 board feet of lumber. That is, with a 50 per cent. gain in diameter there is an increase of 100 per cent. in the product. This is not the whole story, because with the increase in the size of the tree the boards are wider and have less knots, yielding a higher price; so that the gain in money value is even greater than the increase in volume. An average chestnut tree 10 inches in diameter will produce 2 ties and .03 cords of fire wood. Supposing a railroad tie to be worth 50 cents, the tree may be said to be worth about \$1. A 15-inch chestnut will yield 5 ties and .06 cords of wood, worth about \$2.50, or an increase in money value of 150 per cent. In the case of sprout oaks and other sprout hard woods, thinnings made at the right time may result in converting what would otherwise be nothing but a cord-wood lot into one of saw-timber size.

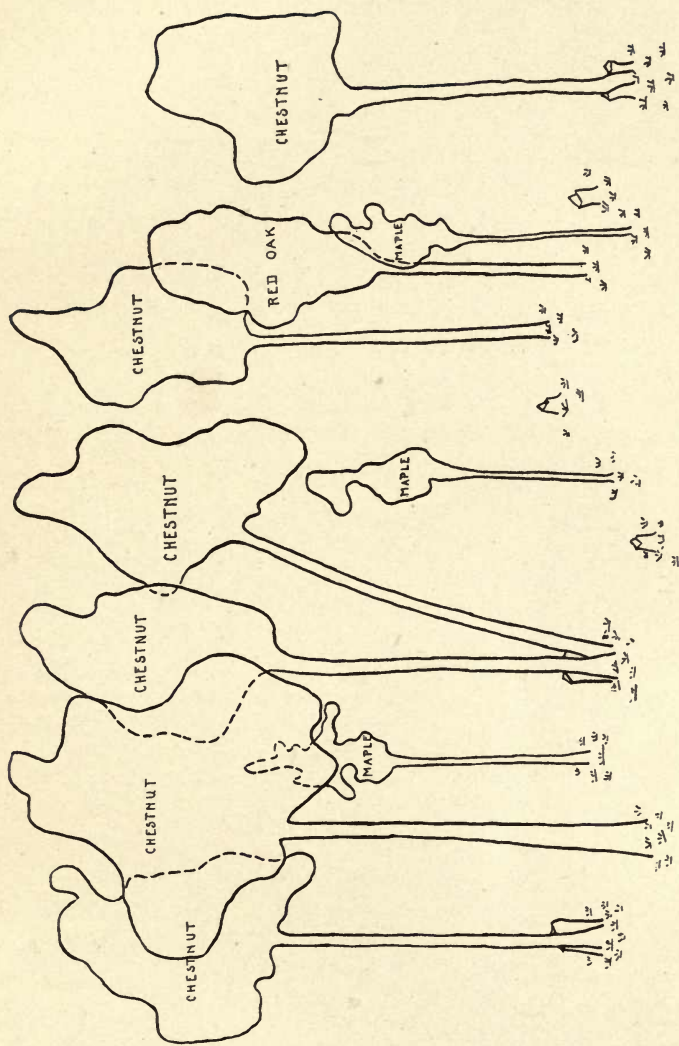
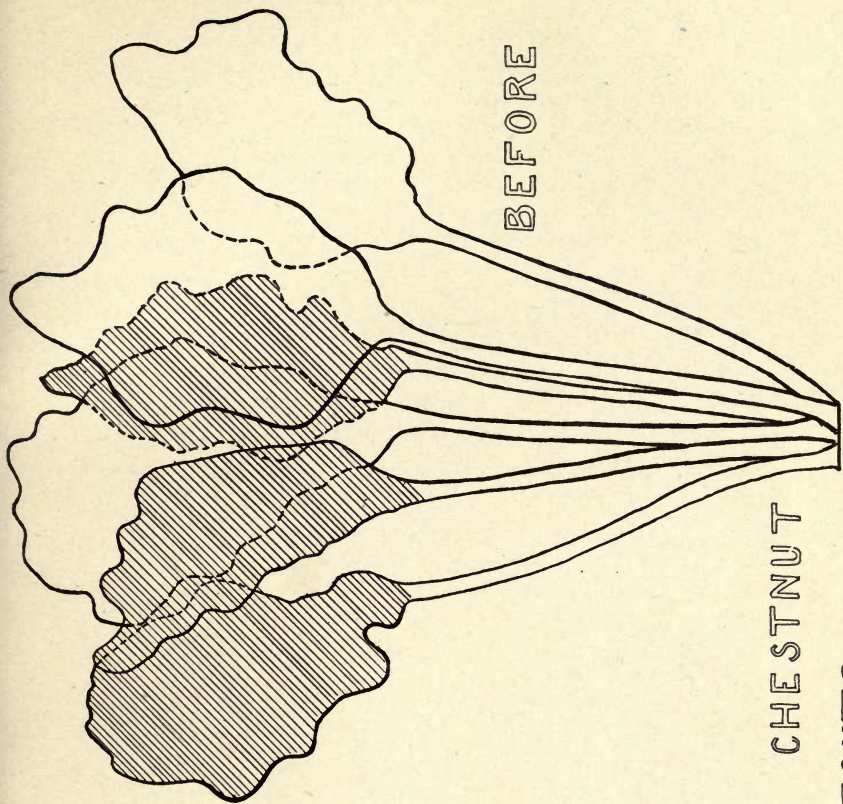


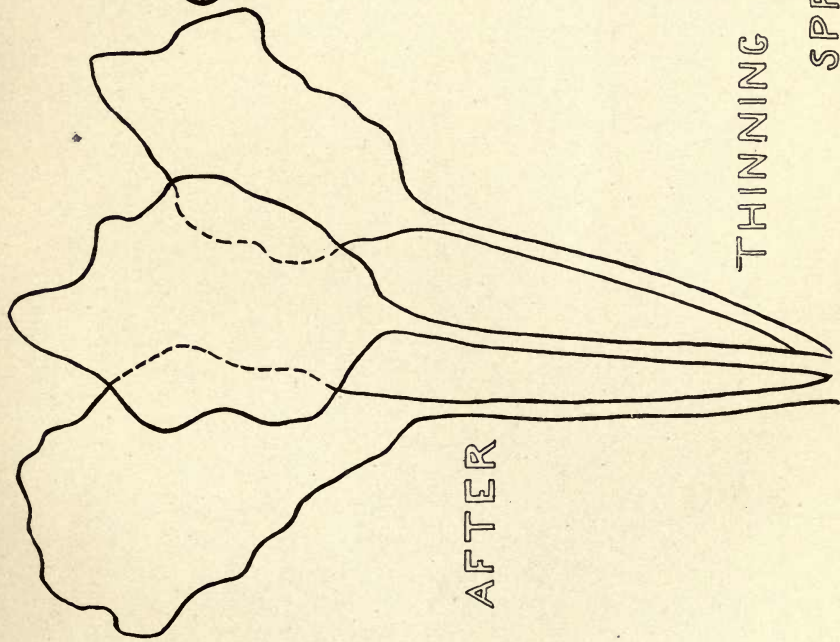
DIAGRAM NO. 2.

BEFORE



THINNING CHESTNUT
SPROUTS

AFTER



If as a result of thinning the trees become larger in a given space of time, conversely they will attain any suitable size in a shorter space of time than without a thinning. The experiments of European foresters have shown that the rotation of the timber crop can be shortened by judicious thinnings from 10 to 20 per cent.

In the course of this work many unsightly and diseased trees are removed, and this fact tends to make the woodland more attractive to the eye. Where forest land is used for park purposes as well as for timber production, a moderate thinning is highly recommended. It should, however, be conducted under careful supervision, as the tendency is often towards a "sand-papering" treatment of the woods, to which many people who love primitiveness in nature object; and they wrongfully believe this effect to be a necessary result of forestry work.

IS THINNING PRACTICABLE?

There are many owners of forest property who, although they do not doubt that a thinning will benefit their woods, say that the cost of the work is prohibitive. Of course there are many places in this State so remote from a market that the product will not even pay the charge for labor; but the trouble with most of these people is, that they want to get back their wages, a fair stumpage, and often an additional profit, from work meant for improvement only. It is an especially valuable line of work for the landowner who is obliged to keep men and horses through the winter months, with little for them to do. Such a man makes something out of the thinning work, no matter if the actual returns are small.

In the sprout hard-wood stands, from 3 to 8 cords will be found to be the usual product of thinnings, depending on the age and density of the stand. In the seedling hard woods and mixed stands the density is so variable as to make any definite statement in regard to the probable product of thinnings impossible. As a rule, about one-third of the trees and from one-fifth to one-quarter of the total volume in the woodlot are taken out in this work.

Two years ago this office published a small pamphlet containing data on the white pine. Part of this booklet was given over to yield tables. A pine yield table is one which shows the volume of well-stocked pine stands at different ages, which in this case ranged from twenty-five to fifty-five years. These tables were made by measuring the trees on many sample plots of all ages, and averaging the results. When these sample plots were calipered, those trees

which would be removed if the stand was thinned were noted separately. From this data a table of the yield from pine thinnings was made and published at that time. We print it again in this pamphlet, on account of its connection with the subject.

YIELD FROM THINNINGS.

Trees under 5 inches, from report of the New Hampshire Forestry Commission, 1906.

AGE (YEARS).	TREES OVER 5 INCHES IN DIAMETER.				TREES UNDER 5 INCHES IN DIAMETER.		
	Board Feet.	Value at \$16 per M.	Stump-age at \$6.	Cubic Feet.	Cords.	Value at \$3 per Cord.	Cubic Feet.
25, ...	1,400	\$22 40	\$8 40	280	7½	\$22 50	750
30, ...	3,700	59 20	22 20	720	6	18 00	600
35, ...	4,950	79 20	29 70	850	4½	13 50	450
40, ...	6,000	96 00	36 00	1,030	3	9 00	300
45, ...	6,800	108 80	40 80	1,140	1½	4 50	150
50, ...	7,400	118 40	44 40	1,240	-	-	-
55, ...	7,900	126 40	49 40	1,310	-	-	-

MISCELLANEOUS CUTTINGS.

There are many kinds of cuttings which one can make to improve woodland, which cannot strictly be called thinnings, because their primary object is not to open up the crown cover, in order to stimulate the growth of the trees. It is not always possible to draw a hard-and-fast line between such improvement cuttings and thinnings, because one may partake of the nature of the other, and the two may be carried out at the same time. Such cuttings can best be suggested by a few examples.

We will suppose that an insect pest which attacks some particular species of tree, for instance, maples, is more or less prevalent in a region. As a matter of protection, the owner of mixed woodland might go through it and take out all the maples, so as not to attract the insects to his land. The removal of hard woods from a pine stand as a precaution in fighting gypsy moths is another protection cutting, which we have described elsewhere in this bulletin.

One often finds among the woods large, spreading old trees, more or less decayed and of little value for timber. It is good forest policy to cut such trees down, and to allow the large amount of ground space which they occupy to come up to a new growth of more value.

In old, abandoned pastures we often see young pines coming up underneath a stand of gray birches. While the pine seedlings are very young, let us say not more than four or five years old, the birches protect them from the hot sun and wind, and act in the rôle of nurse trees. But as the pines increase in size, they need the sunlight; and, further, the branches of the birches, as they sway in the wind, cut the tender leading shoot of the pine, killing it and causing the tree to be stunted and crooked. In such cases the birches should be removed; but if they are too small to make cord wood, or if the young pines are scattered, it is only necessary to remove the trees immediately surrounding the pines. If done in this manner, one man can easily cover an acre or two a day.

If diseased or decaying trees are removed from a stand with no special reference to the principles of thinning, the operation is an improvement cutting, and not a thinning.

THINNINGS IN GYPSY MOTH WORK.

Nowhere are thinnings more useful than in woodland infested with the gypsy moth. The cost of the work against this pest, may it be spraying, burlapping, or creosoting egg clusters, is in a large measure proportional with the number of trees to be treated. One of the first methods used in the work against the gypsy moth in woodlands is to remove the underbrush, and in that way reduce the material to be worked on as much as possible; and it is extremely beneficial, as well as advisable, at the same time to carry on a scientific thinning, and remove from the woods all the trees which will not compose the final stand.

A thinning made in preparation for the work against the gypsy moth should be of the heaviest nature possible, consistent with a fair protection to the soil.

A change is also necessary in the preference of species, the gypsy moth being especially fond of oaks; and it is also hard to detect the egg clusters on white oaks, so that as far as possible they should be removed from the final stand. The gypsy moth caterpillars do not seem to be as fond of hickory, walnut, ash, chestnut or swamp maple as they are of most of the other species of deciduous growths. From experiments which have been carried on in a very thorough manner, it has been proven that the small gypsy moth caterpillar cannot feed upon the conifers; and where thinning operations are being carried on, and a mixed growth must be taken into consideration, it is advisable to separate the conifers from the deciduous growth, thus giving an opportunity to use tanglefoot and protect

the conifers, as they do not hold as much poison as the broad-leaved trees. Also, where pine stands have a small scattering of deciduous growth mixed with them, they may be spared from the ravages of the gypsy moth by removing all deciduous trees, and in that way insure the owner permanent protection, providing he protects the border of the coniferous growth.

It might be well to mention that the brown-tail caterpillars will not feed upon the coniferous growth.

Within any part of the State where there is danger of a moth infestation, the woodland owner will not only improve the condition and growth of his forests by thinning, but will be in a position to combat these pests in a more effective and economical measure than otherwise.

EXPERIMENTAL WORK.

The office commenced this fall to make some permanent sample plots, with the purpose of obtaining data on the growth of thinned stands.

The first of these plots was in a sprout chestnut stand of thirty years' growth, situated near the bottom slopes of the northeast face of a rocky hill. The soil is thin, but fertile and moist. The sample plot covered $\frac{1}{2}$ acre, and within this area the trees to be removed in the thinning were blazed. All the trees were then calipered, the blazed trees being noted separately from the others, with the result that the total stand on the $\frac{1}{2}$ acre amounted to 15 cords of chestnut and 2 cords of miscellaneous wood. The following table represents the tally sheet, and shows the different species and their proportion in the mixed growth. The trees in Class II. are those that were marked for thinning.

SAMPLE PLOT FOR CHESTNUT THINNING ($\frac{1}{2}$ ACRE).

DIAMETER BREAST HIGH (INCHES).	CLASS I.					CLASS II.					
	Chestnut.	Red Maple.	White Oak.	Red Oak.	Gray Birch.	Chestnut.	Red Maple.	White Oak.	Red Oak.	Gray Birch.	Dead.
2, ...	-	5	-	2	-	-	20	5	3	9	3
3, ...	-	3	2	1	-	-	15	17	7	18	16
4, ...	-	-	2	2	-	4	3	5	2	1	22
5, ...	1	2	2	2	-	15	-	-	2	-	5
6, ...	11	-	-	1	-	24	-	-	-	-	2
7, ...	22	-	-	-	-	16	-	-	-	-	-
8, ...	20	-	-	-	-	4	-	-	-	-	-
9, ...	25	-	-	-	-	3	-	-	-	-	-
10, ...	13	-	-	-	-	3	-	-	-	-	-
11, ...	3	-	-	-	-	-	-	-	-	-	-
12, ...	2	-	-	-	-	-	-	-	-	-	-
13, ...	1	-	-	-	-	-	-	-	-	-	-
Totals, . . .	98	10	6	8	0	69	38	27	14	28	48

Average Heights.

	Feet.		Feet.
Chestnut, Class I., ...	57	Red oak, Class II., ...	35
Chestnut, Class II., ...	50	White oak, Class II., ...	37
Red oak, Class I., ...	51	Red maple, Class II., ...	24

The marked trees were then cut down, chopped into 4-foot bolts, and piled as follows (only the larger, sound dead wood was cut into cordwood) :—

	Cords.
Trees (not bolts) 5 to 7 inches breast high diameter, ...	1.3
Trees (not bolts) 7 to 9 inches breast high diameter, ...	.6
Trees (not bolts) 3 to 5 inches breast high diameter, ...	.4
Trees (not bolts) 1 to 3 inches breast high diameter, ...	.2
Dead wood, ...	.8
Total, ...	3.3

To summarize, if this entire chestnut lot, running 30 cords to the acre, were thinned, we would take out more than one-half the total number of trees yielding about 6 cords of wood per acre, or one-fifth of the total volume.

Unfortunately, a fire ran through the woodlot soon after the work was completed, and, although it was not hot enough to injure

the trees severely, their growth will be impaired in some degree, and the value of the lot for future measurements is destroyed.

In the town of Petersham we found an old pasture, containing a thick growth of gray birch, among which a lot of young pines now about twelve years old showed in an ideal way their struggles to get above their grasping neighbors. A half-acre sample plot was measured off, and all the birches cut on one-half of this plot. The other quarter-acre was not touched, so that there could be a comparison made of the difference in the growth of the pine on the improved and unimproved sections. If our theory proves correct, a very few years will suffice to show the difference.

Two men spent two and one-half days in getting out the birch and piling the brush, and the usable product was 4 cords of fire wood.

In the fall of 1907 Mr. J. J. Dearborn, then assistant in this office, marked for a thinning a pine lot of 12 acres, belonging to Dr. P. W. Goldsbury, in Warwick, Mass. When the time came to let out the contract for chopping the trees, no lumberman would take it, saying that such work was impracticable, as it would be impossible to fell the trees without lodging them. Mr. Dearborn then gathered together a crew of his own, employing them as day laborers. After spending a couple of weeks with them at the start of the work, he allowed the crew under the direction of a practical woodsman to complete it, and the result was satisfactory in every way. No insurmountable difficulties appeared in either the chopping or the logging.

Mr. Dearborn's report, describing the conditions, explaining the methods of work, and showing the financial results, forms a valuable document, and we herewith reproduce it.

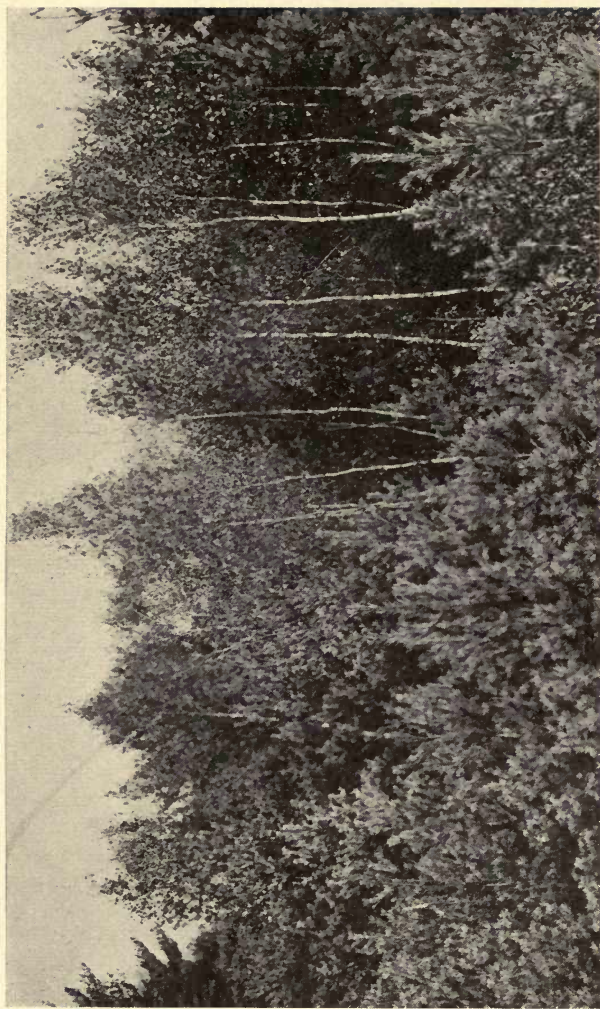
REPORT ON THE PRACTICAL THINNING OF A WHITE PINE WOODLOT.

INTRODUCTION.

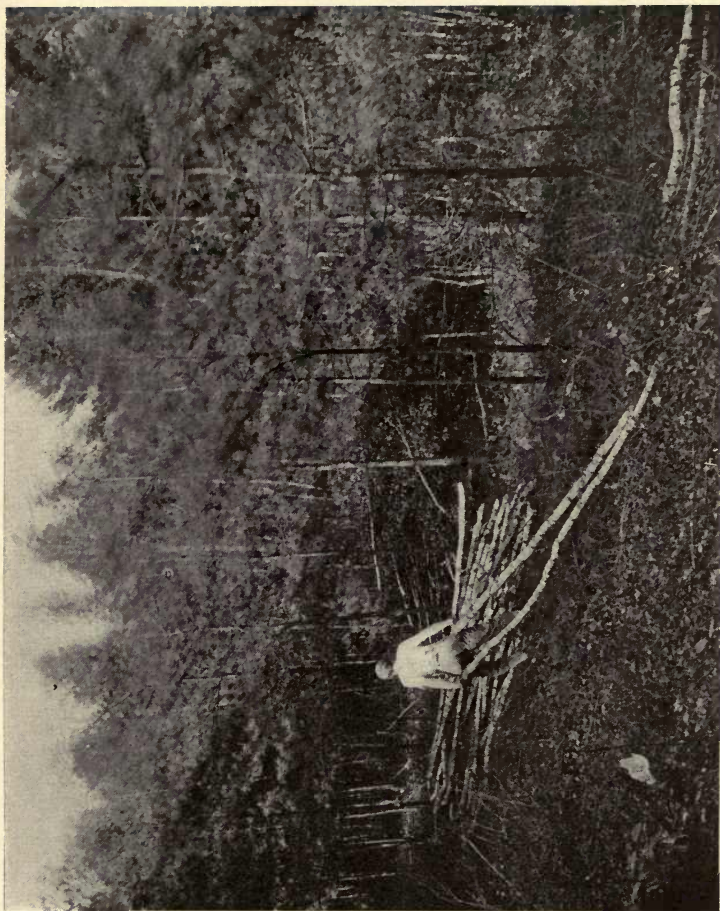
The following report is a record of the conditions and facts connected with the experimental thinning of a white pine woodlot in Warwick, Mass., belonging to Dr. P. W. Goldsbury.

THE TRACT.

The tract extends over an area of 12 acres of gradual swales and ridges at the bottom of a valley. Excepting for a small area where a ledge outcrops or lies very near the surface, the soil is a deep, sandy loam of good moisture, and everywhere well drained.



SAMPLE PLOT, GRAY BIRCH AND PINE, BEFORE IMPROVEMENT CUTTING
(EXTERIOR VIEW).



SAMPLE PLOT, DURING CUTTING (INTERIOR VIEW).

The stand, which averages fifty years of age, is interrupted by two small ponds from being a block of solid growth. This growth is a result of a natural seeding of an old pasture. As a result of this natural seeding, there are represented two conditions which governed the policy of the thinnings, — the first that of a dense condition where the trees had practically started at the same time and grown up to form an even-aged stand, tall and comparatively clean of their side limbs. A sample plot taken in this condition will better illustrate it:—

PLOT $\frac{1}{4}$ ACRE, SOUTH OF BAPTISM POND, IN DIRECTION OF THE HOUSE.

	DIAMETER BREAST HIGH (INCHES).													
	6	7	8	9	10	11	12	13	14	15	16	17	18	22
No. of trees, .	3	5	3	9	8	4	7	7	7	3	4	2	2	2

A total of 66 trees, or 264 to the acre, with a height of 65 to 70 feet.

PLOT $\frac{1}{4}$ ACRE, ON THE FLAT BETWEEN THE TWO PONDS.

	DIAMETER BREAST HIGH (INCHES).											
	5	6	7	8	9	10	11	12	13	14	15	16
No. of trees,	2	3	12	12	13	14	12	6	9	4	3	1

A total of 91 trees, or 364 to the acre, with a height of 60 to 70 feet.

A better idea of the density of these trees can be realized if it is known that 302 trees spaced regularly over an area would be 12 by 12 feet apart.

The other condition was that where a few trees had started and developed very wide spreading, and with large side limbs near to the ground. The density varied from a condition where the side limbs of the trees came together and completely shaded the ground, to where the trees stood with open spots and areas about them. In these open areas there was almost always a good reproduction of white pine coming in among the blueberry, huckleberry and kalmia bushes. The following sample area was taken where the pines had a great deal of room about them, with a good reproduction of pine coming in:—

PLOT $\frac{1}{4}$ ACRE, NORTHEAST OF LARGE POND, IN DIRECTION OF A FIELD.

	DIAMETER BREAST HIGH (INCHES).				
	9	16	18	22	24
No. of trees, ...	1	1	1	1	1

A total of 5 trees, or 20 to the acre, with a height of 55 to 60 feet.

OWNER'S DESIRE.

It was Dr. Goldsbury's first desire not to mar the beauty of his farm, or to make his woodlot an eyesore to the village of his town by cutting and stripping the land of its fine growth. Furthermore, he desired to take such steps as would improve his lot and place it in a more flourishing condition, so that it would come down to the younger generation unimpaired. Lastly, his difficulty in getting any one to attempt the thinning of his lot influenced him to sacrifice his woodlot to an experiment which would make a basis of calculations for such work in the future.

GENERAL POLICY.

For the first condition above mentioned or the even-aged growth, the plan was to thin out the weak and poorer trees, leaving the good specimens with sufficient room for their tops to spread and develop without retardation for some ten years at least. The ground for this policy was based on the fact that the trees had made their main height growth, and their energies were now towards developing their diameters. The growth in diameter of a tree is in proportion to the size of its top, since the leaves are the laboratories of the food material which goes to make up the growth,—the more laboratories, the faster the growth.

With this theory in mind, actual practice meant leaving the better and more promising individuals with sufficient room about them to allow the tops to grow unchecked for at least ten years. If this is successfully accomplished, the trees will have developed a larger top, more laboratories or a larger feeding area.

The following data shows the proportion of trees in number and volume removed and left on the same area:—

	DIAMETER BREAST HIGH (INCHES).																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Trees removed,	6	17	31	30	38	40	17	18	12	10	3	-	2	1	-	-	-	-
Trees left,	1	1	3	10	16	32	19	36	36	32	29	24	24	10	4	4	4	1

A total of 225 removed and 286 now standing; in volume (according to Massachusetts volume tables), 27,050 B. M. feet were removed and 50,140 B. M. feet left; in fact, about two-fifths of the trees in number and one-third the volume were taken out in the thinnings.

For the second condition the policy was that of encouraging a natural regeneration where a good reproduction did not exist, and assisting a good reproduction where it did exist. Wherever the trees were close enough together, so as to form a complete shade, certain

of the poorer specimens were taken out, allowing light to enter and encouraging the growth of any seedlings.

Wherever a good reproduction had started around or underneath any of these large pines, better known to lumbermen and foresters as the "pasture pines," they were removed, taking care to destroy as few of the smaller or young trees as possible.

Through the entire work there were not any hard-and-set rules which could be followed entirely, for there was here and there a problem which could be decided only on the spot. Around the edges of the stand, thinning if carried on at all was not very heavy, since it was thought that too much sun and wind would be admitted from the sides. The presence of a ledge outcropping and lying very near the surface in one instance resulted in a very light thinning, since it was thought that the stand on it was liable to windfall. Other local problems were treated in like manner, but as a rule the main ideas were not deviated from.

THE OPERATING.

Every tree to be removed was blazed with a hatchet, in order that the choppers might not make any mistake. In marking, care was necessary in order to mark those with which there would not be any difficulty in felling. Oftentimes it was necessary to remove trees where some difficulty could not be avoided; yet there were also times when a little foresight would obviate any trouble and still allow good specimens to remain. A little time was sufficient to mark an area which would take some time for the choppers to cover.

The choppers were most efficient in gangs of three. One man, going ahead, would under-cut tree just above the ground and on the side towards which it was to fall. It is remarkable to observe the skill some men have in directing the tree through any small opening by the right position of this under-cut on the tree. The other two men following him would saw just above and on the opposite side of the under-cut until the tree fell. It was the first man's duty now to trim the tree of its side branches and mark the tree into logs with lengths most economical for it to be sawed by the other two men.

This system sounds bunglesome to relate, but, once started, one man should not be interrupted or in the way of the others, and under ordinary conditions the work would be about equally portioned.

Frequently a tree was found so wedged in between its neighbors, their limbs interwoven, or so balanced in regard to its necessary felling direction, that some means was required to give the tree a start before it would fall. This was overcome in large trees by wedging the stump and bole in the saw-kerf, or in small trees by directing the men to throw their weight against the tree. Other methods were: picking up small trees and carrying them away at the bole in the opposite direction they were to fall; felling other trees against the one which does not start;

and, finally, the most useful method,—that of turning the tree with a cant-hook, twisting its top in the direction of least support until it gains momentum sufficient to crash to the ground.

The labor of chopping over the 12 acres required 748 hours. Over this area many of the so-called “pasture pines” were removed, which always tended to make the average cost high, since so much time was required to rid them of their side branches. The fact is that the more expensive trees were removed and the least expensive to handle were left.

Good woodsmen are obtained for \$2 per day, or for 74.8 days an expense of \$149.60 over the whole work. The logs were sawed “live-run” into 2 $\frac{1}{8}$ -inch plank with 1-inch sidings, and according to the mill scale totaled between 125,000 and 130,000 B. M. feet. Upon the basis of 130,000 feet, the average cost would be \$1.15 per thousand for the felling and sawing into logs.

The ordinary contracting price when cutting clean is around \$1 per thousand,—sometimes a little more and sometimes a little less; as a rule, however, a little more, getting as high as \$1.30 per thousand. The chopping of this lot clean would have cost \$1 to contract.

Since it was foreseen that the removing of the “pasture pines” was sure to add to the average cost of chopping the improvement thinnings, a record was kept of the labor and the material removed from an area where the work was entirely that of thinning. It required 112.5 hours to go over 2.5 acres, where 27,000 feet were removed and 50,000 feet left. At the rate of \$2 per day, \$22.50 was the cost of the work of the improvement thinning, or an average of \$0.83 per thousand by day labor.

The logging of this tract was done upon a low, four-wheeled truck for two horses, since it was found to be more handy in driving about the trees than the ordinary wooden-shod sled or “skid.” On snow a traverse sled was used. A few of the trees had to be snaked out with a horse, but ordinarily two men could handle the logs by actually picking them up and carrying them to the sled or truck. The ordinary contracting price for logging this lot would not be over \$1.50 per thousand, and the additional expense for picking the logs up from among the trees left standing was not over \$0.15 per thousand.

CONCLUSION.

Up to date (December, 1909) there are no bad results in the stand left.

From a practical standpoint there seem to be quite definite conclusions that it is possible to thin out a pine growth fifty years of age with an additional cost of not over \$0.15 per thousand for chopping and \$0.15 per thousand for the logging under ordinary conditions.

JOSEPH J. DEARBORN.



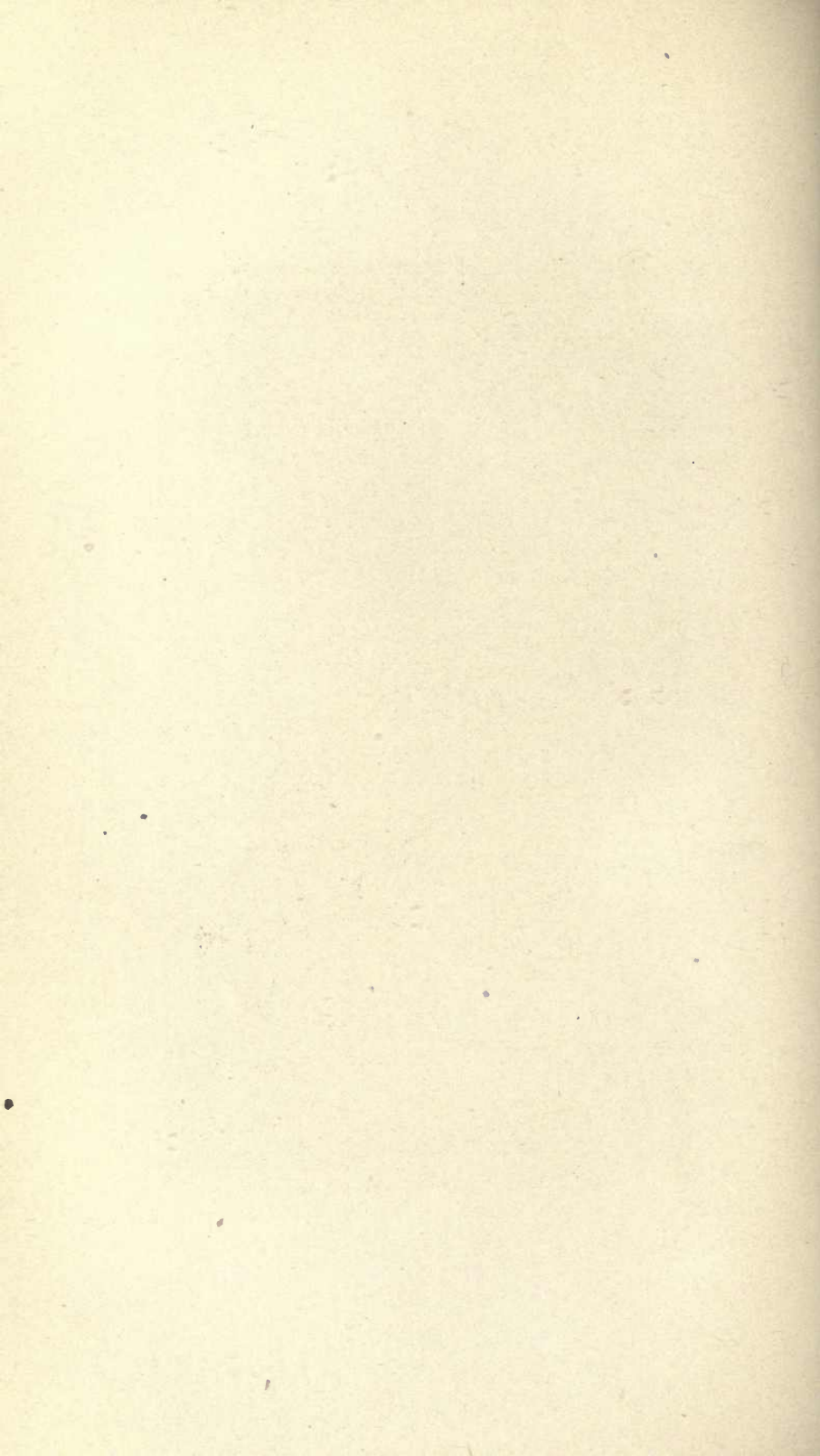
**GOLDSBURY LOT, GUIDING THE FALL OF A LODGED
TREE BY USE OF THE CANT DOG.**

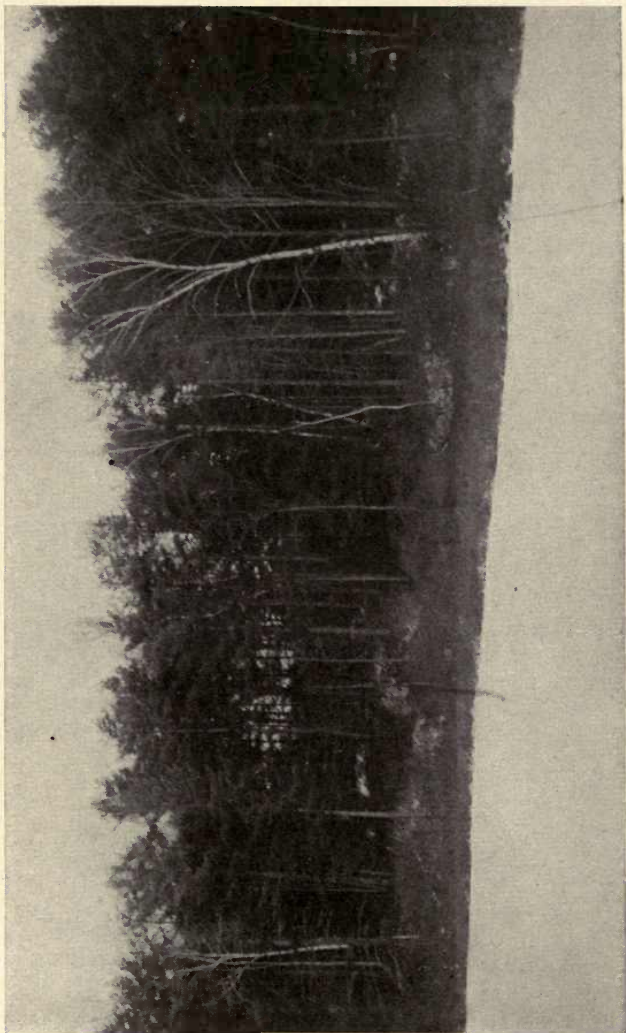


**GOLDSEBURY LOT, DURING THINNING
(INTERIOR VIEW).**

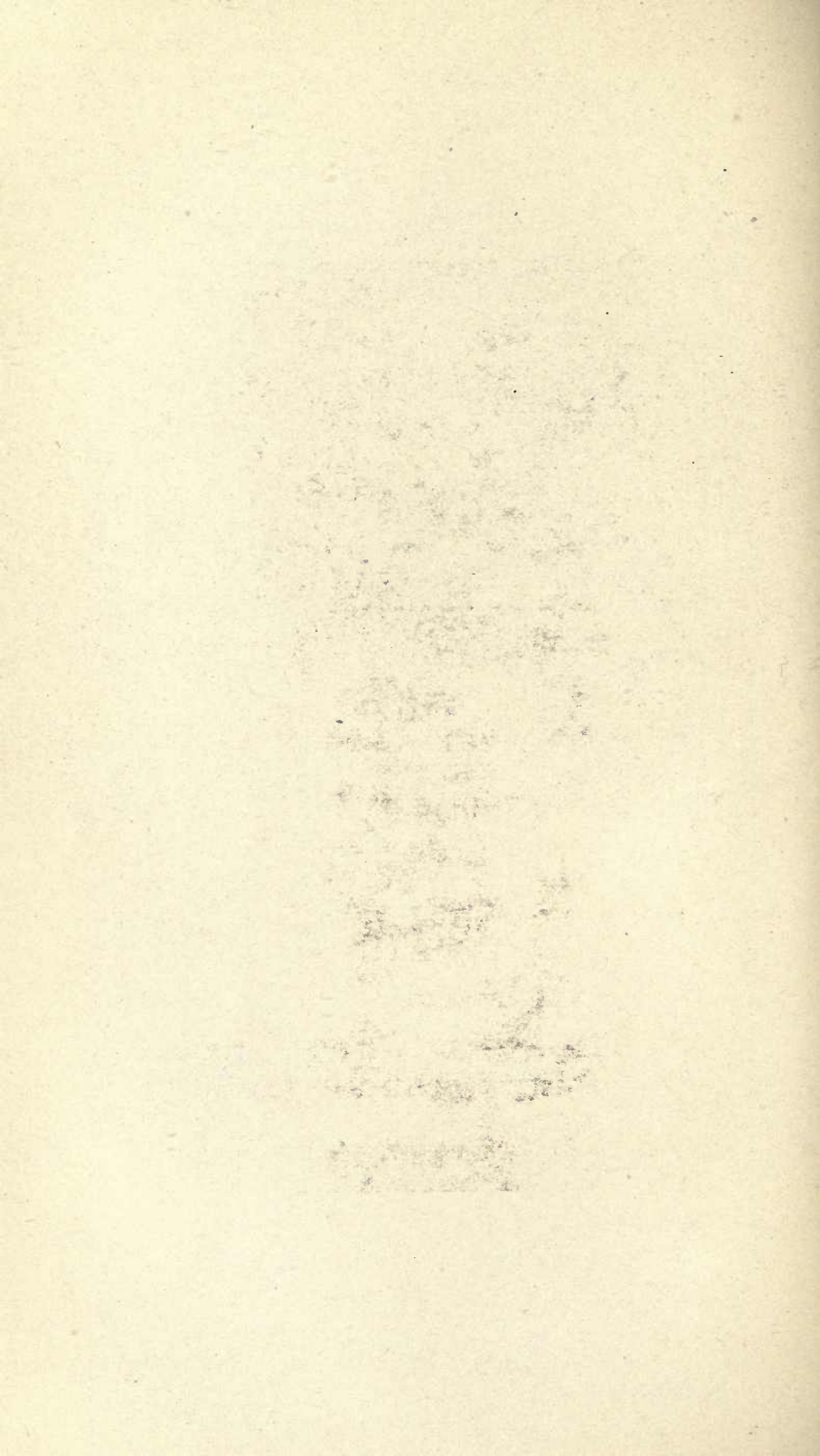


GOLDSBURY LOT, LOOKING UPWARD AFTER THINNING (BEFORE, ONE COULD NOT SEE THROUGH THE TOPS).





GOLDSBURY LOT, AFTER THINNING (EXTERIOR VIEW).



APPLICATION FOR EXAMINATION.

Should you desire an examination for thinning send to the State Forester for a blank application like the following, fill it out and send it in:—

No.....

Received.....



APPLICATION
FOR AN
EXAMINATION OF FOREST LANDS
TO THE
MASSACHUSETTS STATE FORESTER,
STATE HOUSE, BOSTON.

The State Forester stands ready at all times to promote the perpetuation, extension and proper management of the forest lands of the Commonwealth, both public and private (1904, chap. 409, sec. 2).

If you have such lands and desire an examination of them and advice as to their management, fill out the following blank form and send it to the above address of State Forester.

Upon receipt, this request will be placed on file, and you will be informed, in order of application, approximately when the examination can be made, and a mutual date can then be decided upon.

The only expense the applicant promises to pay is that of travel and subsistence of the State Forester or his assistants, incurred in making the examination.

It is always more satisfactory to personally meet on the property the owner or party most interested, at least when the preliminary examination is made. In this way a definite understanding can be had as to future undertakings, and whether working plans are necessary. Often a preliminary visit to gain knowledge of the problem and give advice on the grounds are all the services needed.

When sending this application in, a brief description of the land will assist us.

With the above understanding, I desire to have an examination made of a tract of land of approximately.....acres, located in the town of.....county of.....State of Massachusetts.

Signed

Address

Date.....19 .

Waller Mufford

FOREST NURSERY

AND REFORESTATION WORK

IN

MASSACHUSETTS



By R. S. LANGDELL, ASSISTANT

UNDER THE DIRECTION OF F. W. RANE, STATE FORESTER

BOSTON

WRIGHT & POTTER PRINTING COMPANY, STATE PRINTERS

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1910

INTRODUCTION.

The State Forester has been anxious to place in the hands of our people some definite information on forest nursery and reforestation work. It is believed that this bulletin will meet the requirements.

Nearly every farm in Massachusetts — in fact, in New England — has its woodlot, or some land suited only to the growing of trees. In most cases such land has been wholly or partly cut off or burned over, and left as barren, worthless tracts, an unsightly addition to the rest of the property.

It is the purpose of this bulletin to set forth a remedy which will bring these waste and denuded lands back into forest growth, and provide a method to keep them in a condition to be a source of revenue to the owner at a very small outlay. If, when a woodlot is cut off, provision is made for restocking it, either by natural reproduction, as the leaving of seed trees, or by replanting it with nursery-grown stock, much headway will be made towards bringing the waste lands of Massachusetts back into forest growth.

Nursery work and that of reforestation go hand in hand though two entirely separate undertakings. It is from the nursery that the young trees are furnished to be used on land to be restocked.

ACKNOWLEDGMENTS.

The work of writing and compiling the data in this bulletin was intrusted to Mr. R. S. Langdell, my assistant, who has for the past three years been devoting his energies to carrying on the nursery work at Amherst, and furthering the reforestation work throughout the State.

F. W. RANE,
State Forester.

REFORESTATION IN MASSACHUSETTS.

THE FOREST NURSERY.

One of the first things in nursery work is the procuring of the seed. In most cases our native trees furnish this in great abundance, though in some years the seed crop is much more heavy than in others, due to climatic conditions. Practically all of the seeds referred to may be easily gathered in almost any locality throughout the State.

Procuring the Seed.

The white pine (*Pinus strobus*), our native pine, bears its seed in the cones or burrs, which generally grow in clusters of twos or threes on the upper branches of the tree. Many persons wonder why it is that they cannot find the seed in the opened cones picked up in any pine grove; in fact, a number of cases have been known where persons have planted the cones which have fallen to the ground in late fall or winter, the scales open and the seed escaped, and expected to obtain a crop of trees. The seed is located two under each scale of the cone, and is about the size of a raisin seed, being provided with a small, bee-like wing, which favors its distribution by the wind. The cones commence to turn brown in this section about the middle of August, and from then on ripen very rapidly, one or two sunny days drying the scales so that they open and set the seeds at liberty. The cones must therefore be picked while green, before the scales have opened, by climbing the tree and picking by hand or with pruning shears. Sometimes a person may be fortunate enough to find a large number where the trees are being cut for lumber, — they are then readily picked into baskets. The squirrels also at times cut off large numbers of cones, which fall to the ground and can be gathered up, care

being taken to select cones which have matured sufficiently for the seeds to be fertile.

After the cones are picked they should be spread out in the sun on a smooth floor (Fig. 1), where they can be raked over from time to time, to aid drying. In a week or two the scales will begin to open and the seed fall out. The cones can then be raked off and the seed swept up. If the cones are then put into a bag and flayed, any remaining seed will rattle out. The cones should be kept from getting wet while drying, as the scales will close and will have to dry thoroughly again before opening. They should also be kept away from birds and mice, which often destroy large quantities of seed before being detected. If a large amount of seed is to be extracted, a drying room with drying racks and screens may be provided.¹

Spruce, hemlock, larch, Norway pine, pitch pine and other coniferous tree seeds can be gathered and extracted in the above manner. If properly stored, the seed in most cases retains its vitality for a number of years.

The seed should be cleaned by winnowing, and then put into bags and kept in a cool, dry place through the winter, to be in readiness for planting the following spring.

The seed of maple, ash and other deciduous trees, except the nut trees, is most readily picked from the tree. The oak, chestnut, hickories, locust and some others ripen their seed in the fall, and shed it to the ground by the action of frost and wind.

Layering Seed in Sand.

It is best in most cases to protect the germinating qualities of nut seeds during the winter by storing in sand.

Layering is a method of storing certain seeds through the winter, and should be resorted to when keeping chestnut, oak, hickories, etc. For this purpose a well-drained slope should be selected, and a hole dug in the ground large enough to hold the seed; a layer of sand about 3 inches deep should then be placed in the bottom, then a layer of seed, followed by a layer of sand, and so on till the seed is stored. It should then be covered about 1 foot deep, to protect it from freezing and thawing. When only

¹ Bulletin No. 73, Forest Service, Washington, D. C.



FIG. 1.—Pine cones spread out to dry, in order that seed may be extracted.

a small amount of seed is to be stored, a large drain pipe set in the ground with the bottom covered with fine mesh wire is very convenient, the seed being layered inside the pipe, to protect it from rodents. A wooden box used instead of the drain pipe will answer the purpose very well, and make it easier to remove the seed in the spring.

Site for a Nursery.

A level, well-drained site should be selected for a nursery, the soil being preferably a sandy loam, not subject to washing and free from stones. It is also well to select a plot near the house, where it will be convenient to take care of, and offer some protection from birds and rodents, which often destroy the seed after it has been planted. A small plot in the garden will be well suited for the purpose.

Preparation for the Seed Beds.

The land to be used for the seed beds should first be well plowed and harrowed till the soil is pulverized. A small amount of well-rotted barn-yard manure, free from weed seeds, may be used to advantage. The beds should then be laid out, the most convenient size being a bed 4 feet wide and any convenient length, with walks 2 feet wide between the beds. If the surface soil retains water it will be well to raise the bed a few inches above the walk, and have it about 1 inch higher in the center than on the sides. This will give the moisture a chance to drain off. After the beds have been made up they should be raked over with an iron rake till all small stones and lumps have been removed and the soil thoroughly pulverized. The beds are then ready for the seed, which may be planted in drills or sown broadcast.

Time to plant Seed.

As a rule, the seed should be planted in the spring, as soon as the ground has warmed up a little, it being generally advisable to plant the seed in drills, to facilitate cultivating the seedlings. If planted broadcast, the seedling growing near the middle of the bed will be limited for light and space.

A Marker.

For making the drills to plant pine seed, a marker made of strips of wood 4 feet long, nailed to cross-pieces on a board, with the strips about 4 inches apart, and so arranged as to make a drill about $\frac{1}{2}$ inch deep, has been found very useful. The marker (Fig. 2) can then be pressed down across the bed. If, each time it is moved, the inside cleat is allowed to rest in the trench previously made by the outside cleat, very uniform drills can be made.

Sowing the Seed.

After the drills have been made, the seed should be sown similarly to any garden seed. In case of pine seed, if sown nearly touching each other, 1 pound would cover a bed 4 feet wide and 40 feet long. After the seed is sown, it should be covered by lightly brushing or sifting a little fine soil over it and firming it slightly. If the marker has been made by nailing strips to a smooth board, the back side can be used for this purpose. Some nurserymen advise making a box bed similar to a hot bed, but with holes in the side to act as ventilators and for drainage, a wire screen protecting the beds from rodents.

Mulching.

As soon as the seed is sown, the beds should be covered over with leaves or needles about 3 inches deep, in order to hold the moisture in the ground and keep an even temperature. This prevents the soil from becoming dry, in which case the seed would not germinate. As soon as the seed commences to appear above ground, the mulch should be carefully removed. Screens for shading should be provided in the mean time, as pine seed does not generally germinate for from two to three weeks.

Shading.

For the first two years most coniferous seedlings need to be protected from the sun (Figs. 5 and 6). For this purpose both screens (Fig. 3) may be cheaply made, using two laths as cross-pieces, and nailing others to them about their width apart. If a lath is nailed on slanting through the middle, it makes the screen

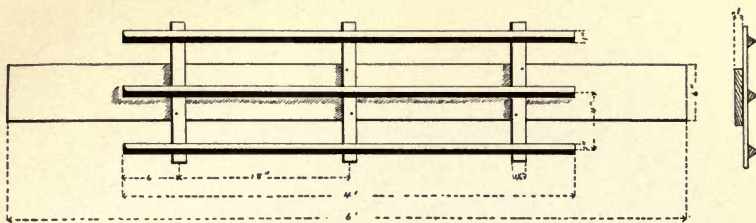


FIG. 2.— View of marker for making drill in which to sow evergreen seeds.

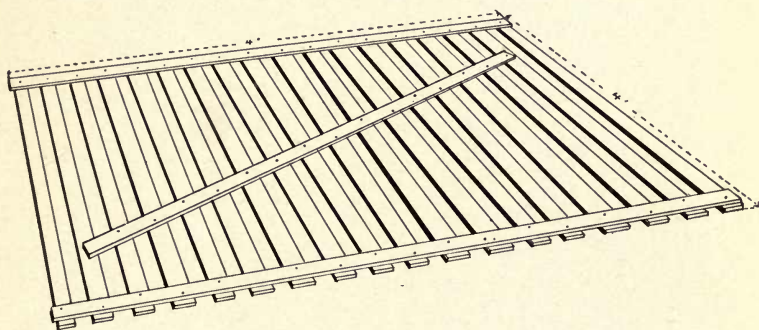


FIG. 3.— View of lath screen to be used in shading evergreen seedlings from the sun

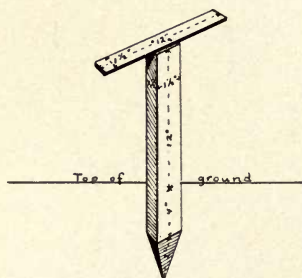


FIG. 4.— Stake to be driven into ground to hold screens above the seed beds.

much more firm. The screens should then be placed about 1 foot above the bed, the laths running north and south. Stakes with a cross-piece 1 foot long nailed on top (Fig. 4), stuck into the ground at each corner of the screens, will hold them in place.

Damping off.

After the seedlings have appeared above ground and the mulch been removed, a dangerous disease to the seedlings is liable to appear, especially if cool, wet weather sets in. This disease causes the seedlings to wilt or die off in large numbers, the stem near the ground rotting off, so that the seedling tips over and dies. The best way to prevent this disease is to remove the screens for a short time each day. Care must, however, be taken not to allow them to remain off long enough for the sun to burn the seedlings, as they are very tender at this stage. If the beds are sprinkled with coarse sand, it also prevents the soil from becoming wet and damp.

The seed beds should be carefully weeded as soon as any weeds appear, care being taken not to root up the seedlings. After the seedlings have obtained a good start, the roots have branched out and a firm hold has been secured, a small hand weeder may be drawn between the drills, to remove the small weeds and at the same time cultivate and fine the soil about the roots of the trees.

Oak, chestnut and other deciduous tree seeds may be sown in beds 8 or 10 feet wide and 25 to 50 feet long, the seed being planted about 2 inches apart in trenches 1 foot apart. This leaves ample space for cultivating seedlings. It is a safe rule to plant seed twice its own depth, as if planted too deep it is liable not to come up till the following spring. Under average conditions, deciduous seeds need not be mulched or shaded. In a short time they should be of sufficient size so that a small hand cultivator may be used.

Protection in the Winter.

In order to protect the tender seedlings from alternate freezing and thawing during the winter, they should be mulched with leaves, pine needles or straw. The screens should then be removed from the seed beds of evergreens, and the mulch spread over the beds to a depth of from 3 to 4 inches. The screens can

then be laid down on the mulch, to hold it in place and prevent it from being scattered by the wind.

The seedlings of deciduous trees need not be mulched, but it is often well to hill them up slightly just before the ground freezes, by piling a little earth up around the stem with a hoe or cultivator. Mulching may, however, be resorted to where the winter is severe.

In the spring, as soon as the snow is off and the frost out of the ground, the mulch should be removed and the screens put up over the evergreen seedlings. Weeding should be done when necessary during the season, from three to four times probably being sufficient if they have been well taken care of in the previous year.

Hardening off of Evergreens.

In the later part of the season, when the sun is not as strong as during the summer, the screens should be removed for a short time each day, a little longer each time, and finally left off altogether. This will harden the plants, and get them into condition to withstand the second winter without mulching, so that they will be ready to transplant in the following spring.

Transplanting.

When the white pine seedlings are two years old, they should be either transplanted in the nursery (Figs. 7 and 8) or set in their permanent sites. It is generally preferable to transplant them in the nursery for one or two years, in order to form a more compact root growth and make a more stocky plant. In the spring, as soon as the frost is well out of the ground (April or May), the seedlings should be dug up and tied in bunches of 50 or 100. In digging, care should be taken not to break off many of the small rootlets. It is also better to choose a cloudy day for the work, rather than a bright, sunshiny day, when there is danger of the roots drying out quickly.

Puddling.

As soon as the trees are dug and tied into bunches, the roots should be dipped into a puddle of mud and water, mixed to the consistency of common paint. This covers the roots with a thin coating of dirt, which prevents their coming in contact with the air and drying out.

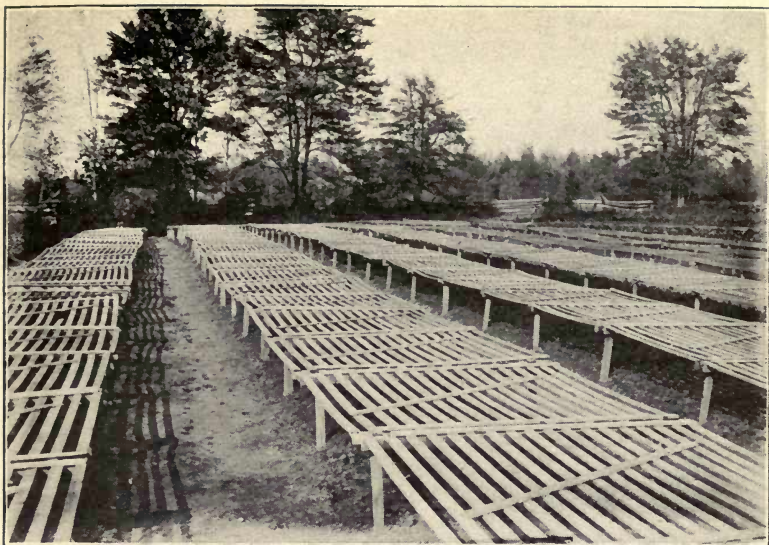


FIG. 5.—Showing method of screening evergreen seedlings from the sun during the first year.

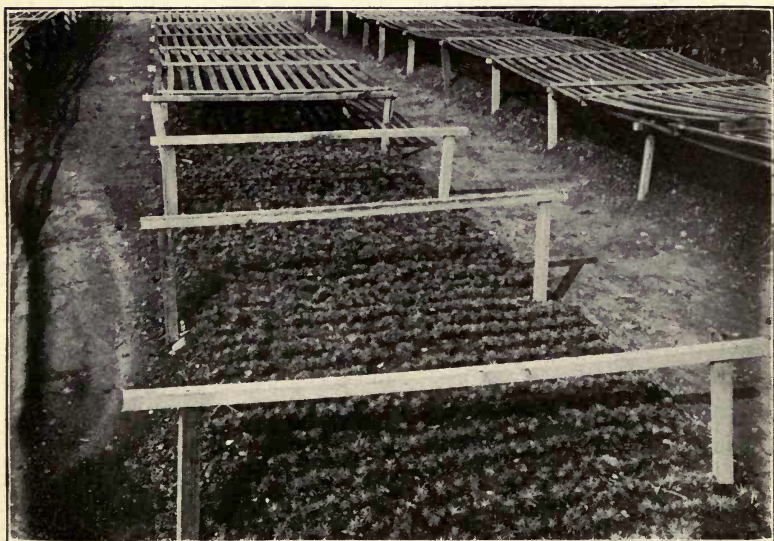


FIG. 6.—View of the seed beds with screens removed, to allow the beds to dry out and prevent damping off.

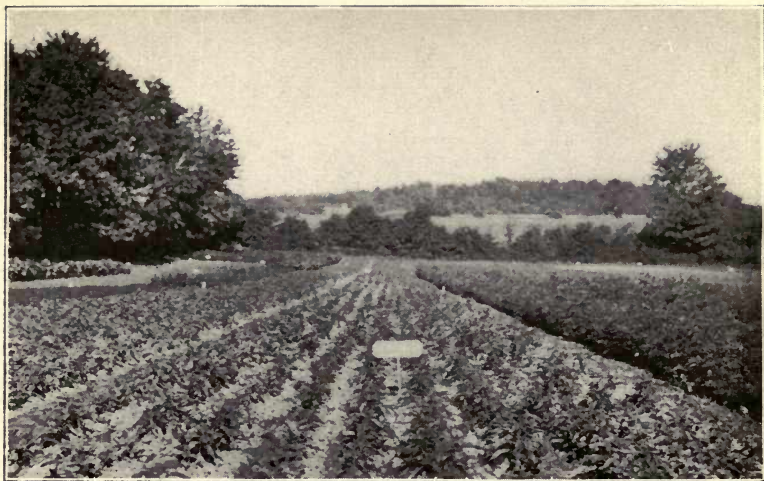


FIG. 7. — View of transplant beds, seedlings being set in rows about a foot apart, to aid in cultivating.



FIG. 8. — White ash transplants, two years old, ready to set in permanent site.

Heeling in Young Trees.

To keep the trees in good condition till ready for transplanting, they may be temporarily set in a trench about 1 foot deep, dug with one side on a slant. The bunches of seedlings may then be placed side by side against the slanting trench, and a little damp soil thrown over the roots and firmed down.

Most hardwood trees should be transplanted when one year old, as they develop a long tap root, which, if allowed to grow for a number of years without resetting, becomes so well rooted that it will be impossible to dig up the plant without serious injury.

Root Pruning.

In order to cause the tree to develop a compact root growth, it is generally considered advisable to cut off a portion of the tap root on deciduous seedlings, such as ash, hickories, catalpa, etc. The cutting off of about one-third of the root causes it to develop a lateral growth.

Packing Seedlings.

When the trees are to be removed to some distance from the nursery, the bunches should be packed in boxes, with the roots in damp sphagnum moss. A layer of damp moss should be put in the bottom of the box, and by alternating the bunches so that the roots will all be in the center, making first a layer of moss, then a layer of trees, and so on till the box is full, a large number may be packed in a small space. It is also well to puddle the roots before packing, giving them an additional coating of soil.

Data on collecting and storing Forest Tree Seeds.

Common Name.	Latin Name.	Cost of Seed.	Number of Seeds per Pound.	Time to collect.	Storage.	Time to plant.
White pine, ...	<i>Pinus strobus</i> , ...	\$2 00	29,000	August to September, .	Dry and cool, .	Spring.
Pitch pine, ...	<i>Pinus rigida</i> , ...	3 50	20,000	October to September, .	Dry and cool, .	Spring.
Red pine, ...	<i>Pinus resinosa</i> , ...	6 00	75,000	September to October, .	Dry and cool, .	Spring.
Scotch pine, ...	<i>Pinus sylvestris</i> , ...	-	-	September to October, .	Dry and cool, .	Spring.
Norway spruce, ...	<i>Picea excelsa</i> , ...	75	80,000	September to October, .	Dry and cool, .	Spring.
European larch, ...	<i>Larix europaea</i> , ...	1 25	9,000	September to October, .	Dry and cool, .	Spring.
Arbor vitae, ...	<i>Thuja occidentalis</i> , ...	2 50	70,000	September to October, .	Dry and cool, .	Spring.
Hemlock, ...	<i>Tsuga canadensis</i> , ...	5 00	65,000	September to October, .	Dry and cool, .	Spring.
Rock maple, ...	<i>Acer saccharum</i> , ...	1 00	7,000	September to October, .	Layer in sand, .	Spring.
White ash, ...	<i>Fraxinus americana</i> , ...	60	10,300	October, ...	Layer in sand, .	Spring.
Tulip tree, ...	<i>Liriodendron tulipifera</i> , ...	75	9,000	October, ...	Layer in sand, .	Spring.
White birch, ...	<i>Betula papyrifera</i> , ...	2 00	482,000	September to October, .	- - -	At once.
Beech, ...	<i>Fagus ferruginea</i> , ...	75	1,800	October to November, .	Layer in sand, .	Spring or fall.
Chestnut, ...	<i>Castanea Dentata</i> , ...	40	98	October to November, .	Layer in sand, .	Spring or fall.
White oak, ...	<i>Quercus alba</i> , ...	50	90	September to October, .	Layer in sand, .	Spring or fall.
Red oak, ...	<i>Quercus rubra</i> , ...	25	78	September to October, .	Layer in sand, .	Spring or fall.
Hickory, ...	<i>Hicoria ovata</i> , ...	35	80	September to October, .	Layer in sand, .	Spring or fall.
Black locust, ...	<i>Robinia pseudacacia</i> , ...	65	30,000	October, ...	Dry and cool, .	Spring or fall.

Cost of Seedlings and Transplants per Thousand.

VARIETY.	PRICE OF AMERICAN TREES.			PRICE OF FOREIGN TRANSPLANTS. ¹		
	1 Year.	2 Years.	3 Years.	2 Years.	3 Years.	4 Years.
White pine, . . .	-	\$3 00-\$5 00	\$12 00	\$0 84-\$0 96	\$2 64	\$2 88
Pitch pine, . . .	-	4 50- 7 00	20 00	1 00	3 00	-
Red pine, . . .	-	15 00	-	-	-	-
Scotch pine, . . .	-	4 00- 6 00	12 00	1 20- 1 60	1 80	2 88
Norway spruce, . .	-	6 00	10 00-16 00	36- 60	1 44	2 40
European larch, . .	-	6 00- 8 00	19 00	1 50	2 00	-
Arbor vitæ, . . .	-	5 00	15 00	-	-	-
Hemlock, . . .	-	16 00	-	-	-	-
Rock maple, . . .	\$5 00-\$8 00	12 00-16 00	30 00	-	-	-
White ash, . . .	6 00- 8 00	10 00-18 00	20 00-40 00	-	-	-
Tulip tree, . . .	-	-	20 00	-	-	-
White birch, . . .	6 00	14 00-35 00	30 00-50 00	-	-	-
Beech, . . .	9 00	-	-	-	-	-
Chestnut, . . .	8 00-15 00	20 00-35 00	-	-	-	-
White oak, . . .	10 00-15 00	-	-	-	-	-
Red oak, . . .	7 00- 8 00	10 00-12 00	15 00-35 00	-	-	-
Hickory, . . .	8 00-10 00	12 00-15 00	20 00-35 00	-	-	-
Black locust, . . .	3 50- 5 00	8 00-15 00	-	-	-	-

¹ Freight and charges on imported stock average from \$0.50 to \$0.75 per thousand.

REFORESTATION.

The total area of Massachusetts is about 5,321,787 acres, of which 2,672,950 acres is land adapted only to the growing of trees. Of this area there are about 700,000 acres which at the present time constitute practically worthless tracts, being simply a tax to the owners, who at a very small outlay could bring the land back into a profitable forest growth, as well as adding to the scenic beauty of the section.

This land lies in tracts varying in size from one to thousands of acres. Practically every farm has a portion which at one time or another has been cut off, burnt over, or allowed to relapse into a condition where it is no longer a source of revenue, but a piece of property which brings in no return, though it is still taxable. Lumbermen, mill owners, water-right companies and farmers all have some land which falls under one of the following types, and it is this sort of land which fortunately furnishes ideal conditions for forest planting.

Cut-over Land (Fig. 9).

It can be safely said that every lumberman owns one or more tracts of land which he has cut off, but which has not come back into a growth which will ever be of any great profit to himself

or others, if allowed to remain in its present condition. Nature intends that this land should remain in forest growth, but through inconsiderate cutting it has come up to an undergrowth of small value. It is always preferable to restock this type of land as soon as possible after it has been cut, as the sprout and hardwood growths, if allowed to gain too great a headway, will hold the seedlings in check.

Burnt-over Land (Fig. 10).

On land which has been subjected to repeated fires, destroying the growth and ground cover, the soil is left free to the action of the weather, to be quickly dried out by the sun, or, if on a side hill, to be washed into the valley by rains. The seed or seedlings which may have been on the ground have been destroyed, and the land might lie for a long period of years before it would reseed itself naturally. Land of this type, therefore, should be set with considerable care, in order to obtain the best results. It is generally advisable to set a three-year-old or four-year-old transplant here, rather than seedlings.

Run-out Pasture Land (Figs. 11 and 12).

Many of the farms throughout the State are becoming run out, and are allowed to grow up to brush and undesirable hardwoods. Pasture lands especially are being encroached upon by some of our less valuable trees, such as bird cherry and gray birch, which so overshadow the ground that good pasturage runs out, and the lot is abandoned for fields affording better forage. In many cases scattering white pine have crept in, and probably in time would seed in the whole piece; but the old trees, while doing good work in reseedling, would be of little value, as, growing so scattered, they would develop large lateral branches, instead of giving a clear, straight bole to the trunk, so desirable in the best grade of lumber. If the lot could be set out with seedlings and the trees allowed to grow in sufficiently dense stands, the lower branches would die off naturally, and smooth, clear lumber would be assured.



FIG. 9. — Cut-over land, suitable for restocking with white pine. The sawdust pile tells the story.

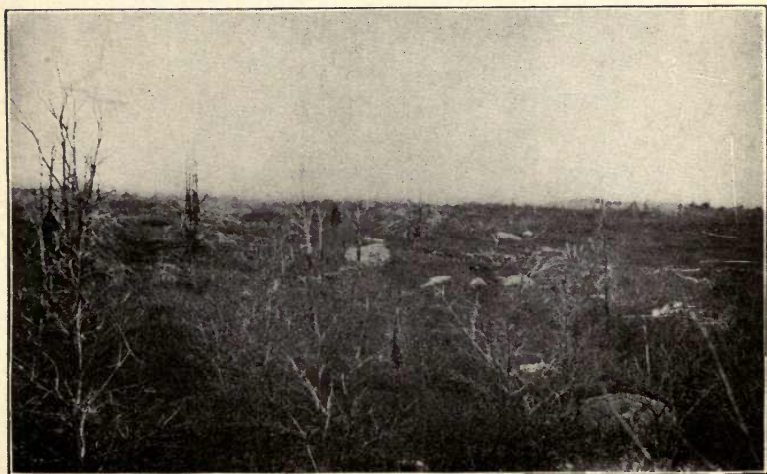


FIG. 10. — Burnt-over land, where all the seed and young trees have been destroyed by repeated fires. Land should be reforested.



FIG. 11.—Run-out pasture land, which should be brought back into forest growth.

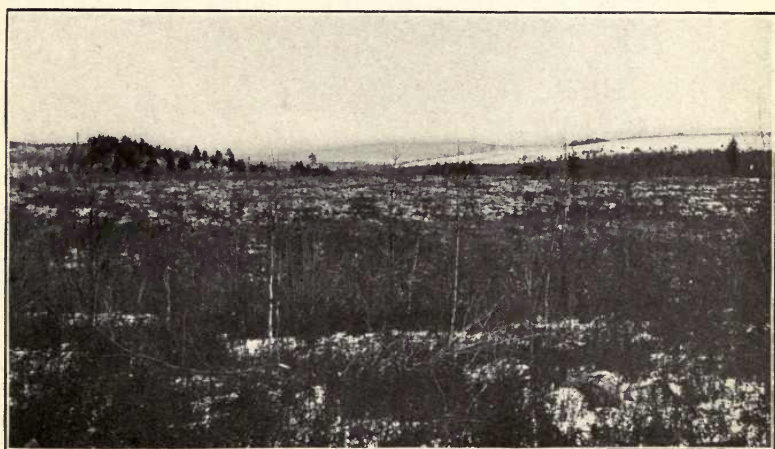


FIG. 12.—Land coming up to gray birch and undesirable hardwood, and which should be reforested.

Seedlings and Transplants.

It is generally considered advisable to set transplants rather than seedlings, although under most conditions in this section the two-year-old white pine has been planted with good results. As a rule two-year-old seedlings may be planted on land classed as run-out pasture land or on cut-over land with good success, there being a little shade afforded by gray birch or low bushes.

Three-year-old or four-year-old transplants are adapted for planting on open land, exposed to the drying effects of sun and wind (Fig. 13). As their root growth is large, they can be more deeply set in the ground where they can take up the moisture; whereas, if the roots were near the surface, as they would necessarily be if seedlings were used, the trees would die from lack of moisture in the top soil. It is also best to set transplants in old fields or mowings, where small plants would be beaten down and choked out by the thick fog or dead grass.

Varieties to plant

There are a number of varieties of trees which may be planted with good results. It is advisable to set some tree which grows naturally in the locality in which the work is to be done.

The white pine (*Pinus strobus*) (Fig. 14) has been used largely for reforestation purposes throughout the State, and has adapted itself to most of our New England conditions; in fact, this section of the country at one time was covered with primeval forest comprised largely of white pine. The rapidity of its growth and the many uses to which the variety of wood may be put makes it a practical tree for forest planting, and the one most used in this work. It is, however, recommended to use some other variety on Cape Cod, unless the plantation is well protected from the wind, which on the Cape causes a somewhat stunted growth.

The white ash (*Fraxinus americana*) is well suited for planting on a springy side hill, where the growth and texture of the wood of this variety often reaches its highest quality. It is also practically immune from the attack of the gypsy and brown-tail moths, which are so detrimental to the trees in many towns in the eastern part of the State.

The Norway spruce (*Picea excelsa*), a tree grown on an extensive scale in European countries with climatic conditions similar to our own, is a tree well suited for planting in sections where our native red spruce is the predominating species. It is a rapid grower, and its wood is also claimed to have properties for the manufacture of paper pulp not contained in other native trees. This variety has been planted quite extensively in New York State, where excellent results have been obtained.

For planting on Cape Cod, the Scotch pine, pitch pine, Austrian pine, black locust and oak should be used. The Cape conditions vary in a number of ways, and should be looked into to some extent before undertaking to plant the trees. In many sections of the Cape repeated fires have so destroyed the ground cover and even burnt into the top soil that a transplant should be used, whose root could reach down into the soil deep enough to obtain moisture. In other cases a screen of some rapid-growing trees should be planted around the plantation, to act as a protection from the prevailing wind, which often causes the trees to lean. In almost every instance a plantation on the Cape should have some protection from forest fires. The sandy formation of the soil offers great inducement for making and retaining a fire line, at very small expense. A furrow in most cases could thus be made with a plow, and the dry, sandy soil thus turned up would act as a check to a running fire. It could be very easily kept free and clear from dead grass, leaves and brush. In fact, if the towns comprising the Cape could be brought to see the advantage of maintaining a strip 50 feet wide on each side of a town line, many of the large disastrous fires of that section could be prevented. And, as the town lines necessarily have to be blazed or marked every few years, the labor and expense for such work could be done away with. This is a line of work which might receive some attention in other sections of the State, as well as on the Cape. In a number of towns where a rather modified form of the work has been done, it has been found remarkably effective and the expense comparatively small.



FIG. 13. — Land planted with white pine transplants, six years after setting.
Notice remarkable growth of leading shoot.



FIG. 14.—View of thirty-eight-year-old plantation of white pine, showing how the lower branches have died from lack of light, giving a clear, straight bole to the trunk, and producing clean lumber, free from large knots.

Trees suitable for Forest Planting in Massachusetts.

NAME OF SPECIES.	Soil.	Uses.
White pine, ...	Any soil not near coast or swampy, ...	Lumber, box boards.
Pitch pine, ...	Sandy soil, on coast, ...	Lumber, to hold sand in check.
Red pine, ...	Sandy soil, inland, ...	Lumber, ship timbers.
Norway spruce, ...	Sandy loam, ...	Lumber, Christmas trees.
European larch, ...	Light soil, ...	Piles, ship building.
Arbor vitae, ...	Sandy soil, ...	Posts, shingles, etc.
Hemlock, ...	Well-drained soil, or swampy, ...	Lumber, ties, tanning.
Rock maple, ...	Well-drained soil, ...	Furniture, floors.
White ash, ...	Wet land, swampy, ...	Lumber, carriages, tools.
Tulip tree, ...	Sandy loam, ...	Lumber, pulp wood.
White birch, ...	Sandy or gravelly soil, ...	Furniture, fuel, handles.
Poplar, ...	Sandy or gravelly soil, ...	Pulp wood, excelsa.
Beech, ...	Moist loam, ...	Tools, laths, etc.
Chestnut, ...	Well-drained soil, ...	Poles, posts, ties, etc.
White oak, ...	Sandy loam, ...	Agricultural tools.
Red oak, ...	Well-drained soil, ...	Lumber, fuel.
Hickory, ...	Sandy loam, ...	Carriage building, tools.
Black locust, ...	Sandy soil, on coast, ...	Posts, ties, etc.

Nurserymen.
AMERICAN NURSERYMEN.

Northeastern Forestry Company, ...	New Haven, Conn.
American Forestry Company, ...	South Framingham, Mass.
D. Hill, ...	Dundee, Ill.
Evergreen Nursery Company, ...	Sturgeon Bay, Wis.
Garfield Williamson, ...	52 Broadway, New York, N.Y.
Massachusetts State Forester, ...	Boston, Mass. ¹

FOREIGN NURSERYMEN.

J. Heins Sohne, ...	Holstenbeck, Ger.
Julius Hansen, ...	Pinneberg, Ger.
Pierre Sebire & Son, ...	Ussy, Calvados, France.
Dickson Nurseries, ...	Chester, Eng.
Peter Schott, ...	Knittelsheim, Rheinpfalz, Ger.

Spacing of Trees.

In order to produce a dense stand of trees, where the lower branches will die off and fall to the ground from lack of light, giving a clear, straight bole (Fig. 14), so desirable for lumber purposes, the trees should be set 6 feet apart each way, or about 1,210 to the acre. The exact number will necessarily vary according to the condition of the land. On rough, stony tracts,

¹ The State Forester often knows of local growers that have from one thousand to five hundred thousand trees for sale each year, and is glad to give information in regard to them.

where the trees will be set only where there is sufficient soil for the roots to obtain a firm footing, the number of trees may be a few hundred less than on land covered by a good top soil. If the trees are set in rows running from one side of the lot to the other, it will be found quite easy to keep track of the portion which has been set. The distance apart may be very readily determined by making the holes two paces apart, or about 6 feet. It is also generally considered best to make a clear planting, rather than to mix varieties.

Heeling in on Lot.

Where a large number of trees are to be planted, they should be heeled in on the lot in a place where there is some protection from the sun; otherwise, a screen of brush may be put up. It will also be well to choose a spot near a brook or stream, as the seedlings will need to be watered if they become dry before transplanting. After they have been set in their permanent site they will take care of themselves, as to water them when spread out over a large area would be an almost impossible undertaking.

Method of setting the Trees.

The most convenient method of setting the trees is for the men to work in pairs, one making the holes and the other planting the trees. The first man with a grub hoe or mattock should strike into the ground (Figs. 15 and 16) and make a small hole, leaving as much as possible of the soil removed where it can be readily used to place around the roots when the tree is set; then he takes two paces and makes another hole. The second man, carrying a pail containing a bunch of seedlings, the roots of which are in a puddle of mud and water always to be kept in the pail, takes a plant and sets it in the hole (Fig. 17) at about the same depth as it originally grew, covering the roots with fine soil and firming it down by pressure of the foot (Fig. 18). The men should keep together and work from one side of the lot to the other and then back, the rows being kept about two paces apart. If stakes with flags are placed along the outside row and moved from time to time, it will be much easier to follow the row. One man should superintend from six to eight pairs of men.



FIG. 15.—First step in making the hole.



FIG. 16.—Second step in making the hole.



FIG. 17.—Setting the seedling and covering the roots.



FIG. 18.—Firming the soil by pressure of the foot.

Time to plant.

Planting should be undertaken as soon as the frost is out of the ground in the spring, the month of April and first of May being preferable, in order that the young roots may get started before the dry season sets in. Spring planting is preferable to fall planting, as the roots having started will not be as likely to be heaved out by the frost; although under certain conditions fall planting is sometimes resorted to, as in a case where a piece of land is too wet to work in the spring, but becomes dry during the summer and fall.

Two men working in the above manner will set about an acre per day, the expense of reforesting a tract, therefore, ranging from \$5 to \$10 per acre, depending on the price of the trees used and the cost of labor, white pine seedlings generally selling for from \$3 to \$5 per 1,000, and labor ranging from \$1.50 to \$2 per day. The above estimate is based on about 30 lots planted by the State Forestry department, the lots ranging in size from 20 to 200 acres. It was generally found that the average cost is much smaller on large lots than on small ones, the men becoming used to the lay of the land, and thus being able to work with greater speed.

Protection of Plantation.

After the lot has been planted, it needs practically no care unless a large proportion die out, in which case the blanks should be filled in with transplants. The lot should not be pastured, as many of the young trees would be trampled down. It is also well to put up posters prohibiting hunters and berry pickers, who often through carelessness start fires capable of great damage.

Fire Lines (Fig. 19).

Around large lots a fire line should be cut on the exposed side of the plantation, to protect them from forest fires creeping in from adjoining land. A strip 50 feet wide cleaned of brush has been found very effective, the brush being piled and burned when the snow is on the ground (Fig. 20). On the side nearest the plantation (Fig. 20) a trench 6 feet wide should be grubbed up or plowed up, and kept free from weeds and dead leaves. In this way a fire working in from other land would be unable to

jump across the trench, having nothing to feed on. A trench on the outside of the line would also be of advantage; but in case only one trench is deemed advisable, it is better to have it on the inside of the fire line. A line so made will offer a place for checking a fire or back-firing. The cost will vary according to the growth which has to be cleared. In cases where the wood is large enough to put it into cord wood, the expense will be small, the work nearly paying for itself; but under average conditions, where no return can be derived, the cost will vary from \$150 to \$200 per mile. It is best to cut and pile the brush for such a line in early fall, when there will be no danger from sparks or fire running. A strip of this kind is of especial advantage along railroads.

In extremely dry times, when there is danger from berry pickers or hunters, a look-out from some high knoll will be of advantage. A fire patrol of a lot, whether planted, or a natural stand, is practical in dry times. The old saying, that "An ounce of prevention is worth a pound of cure," certainly applies in cases where forest fires are concerned.

REFORESTATION WORK DONE BY THE STATE.

Under "An Act to provide for the purchase of forest land and for reforestation," passed by the Legislature of 1908, provision is made that private land owners may turn tracts of land suitable for reforestation purposes over to the State, to be planted and handled under practical forestry management, such owners reserving the right to redeem the land at any time within ten years, for the actual amount expended.

During the year 1909 about 1,000 acres were deeded to the State and planted under the supervision of expert foresters from the State Forester's office, the work being done by local gangs (Fig. 21) picked up in the various towns where the lots were situated. The cost of planting, including price of trees and labor of setting, ranged from \$5 to \$10 per acre, according to land and labor conditions. A large proportion of the trees used in the work were purchased from outside nurserymen; but in the future, by raising the stock in State nurseries, the above cost of planting should be reduced.



FIG. 19. — Fire line, Metropolitan Water Board reservation, Boylston.



FIG. 20. — Burning brush along a fire line, work being done when the snow is on the ground, to prevent the fire from running. A trench six feet wide indistinctly shown on the left.

Reforestation Act of 1908 (Chapter 478).

AN ACT TO PROVIDE FOR THE PURCHASE OF FOREST LAND AND FOR
REFORESTATION.

Be it enacted, etc., as follows:

SECTION 1. For the purpose of experiment and illustration in forest management and for the purposes specified in section seven of this act, the sum of five thousand dollars may be expended in the year nineteen hundred and eight, and the sum of ten thousand dollars annually thereafter, by the state forester, with the advice and consent of the governor and council, in purchasing lands situated within the commonwealth and adapted to forest production. The price of such land shall not exceed in any instance five dollars per acre, nor shall more than forty acres be acquired in any one tract in any one year, except that a greater area may so be acquired if the land purchased directly affects a source or tributary of water supply in any city or town of the commonwealth. All lands acquired under the provisions of this act shall be conveyed to the commonwealth, and no lands shall be paid for nor shall any moneys be expended in improvements thereon until all instruments of conveyance and the title to be transferred thereby have been approved by the attorney-general and until such instruments have been executed and recorded.

SECTION 2. The owners of land purchased under this act, or their heirs and assigns, may repurchase the land from the commonwealth at any time within ten years after the purchase by the commonwealth, upon paying the price originally paid by the commonwealth, together with the amount expended in improvements and maintenance, with interest at the rate of four per cent per annum on the purchase price. The state forester, with the approval of the governor and council, may execute in behalf of the commonwealth such deeds of reconveyance as may be necessary under this section: *provided, however*, that there shall be included in such deeds a restriction requiring that trees cut from such property shall not be less than eight inches in diameter at the butt.

SECTION 3. The state forester may in his discretion, but subject to the approval of the deed and title by the attorney-general as provided in section one, accept on behalf of the commonwealth gifts of land to be held and managed for the purpose hereinbefore expressed. A donor of such land may reserve the right to buy back the land in accordance with the provisions of section two, but in the absence of a provision to that effect in his deed of gift he shall not have such right.

SECTION 4. Land acquired under the provisions of this act shall be under the control and management of the state forester who may, sub-

ject to the approval of the governor and council, cut and sell trees, wood and other produce therefrom.

SECTION 5. All moneys received by or payable to the commonwealth or any one acting on its behalf under the provisions of this act shall be paid into the treasury of the commonwealth.

SECTION 6. Land acquired under the provisions of this act and subsequently reconveyed under the provisions of sections two or three shall not be exempt from taxation on account of any plantation of trees set out or planted while it was held by the commonwealth.

SECTION 7. For the purpose of assisting in reforestation a portion, not exceeding twenty per cent of the money authorized by this act to be expended may be used by the state forester for the distribution at not less than cost of seeds and seedlings to land owners who are citizens of the commonwealth, under such conditions and restrictions as the state forester, subject to the approval of the governor and council, may deem advisable.

SECTION 8. The state forester shall re-plant or otherwise manage all land acquired by the commonwealth and held by it under the provisions of this act, in such manner as will, in his judgment, produce the best forest growth both as to practical forestry results and protection of water supplies.

SECTION 9. All acts and parts of acts inconsistent herewith are hereby repealed.

SECTION 10. This act shall take effect upon its passage. [*Approved May 1, 1908.*]

The purpose of the above act is to place before the people an example along forestry lines which will aid them in carrying out the work for themselves. For this reason it is desired that the State, as far as possible, take over lots easily accessible to main highways.

In some instances lots have been taken over where it has been deemed advisable to protect the plantations from forest fires by making a fire line, or making provision for some one in the near vicinity to be supplied with fire extinguishers and equipment for fighting fires, and to patrol the lot in exceedingly dry times.

A number of lots have also been acquired where a small portion had some small growth which, if systematically thinned, could be profitably handled (Fig. 22).

Private parties owning land in the State adapted for reforestation purposes should make application to the State Forester, who will gladly furnish advice along forestry lines.



FIG. 21. — A planting gang at work under the reforestation act.



FIG. 22. — View of example in thinning, where undesirable hardwoods have been removed and put into cord wood, to give the undergrowing stand of white pine a chance to grow.



SYLVICULTURAL CHARACTERISTICS OF TREES.

Trees most commonly found growing in Massachusetts, the Uses to which their Timber is put, and a Few of their Most Important Enemies.

For convenience in the matter of reference, we shall separate the different species under three heads: (1) conifers, (2) northern hardwoods and (3) southern hardwoods, the term "hardwoods" being used for all trees other than conifers.

Under (1) will be treated white pine, red or Norway pine, pitch pine, Scotch pine, hemlock, red spruce, and Norway spruce.

Under (2) come rock maple, beech, white birch and yellow birch.

Under (3), chestnut, red oak, white oak, red maple, shag-bark hickory, black locust and white ash.

1. CONIFERS.*White Pine (Pinus strobus).*

This species is placed first, both because of its marked adaptability to growth in this State and because of the universal demand for its lumber.

It may be found growing in all sorts of situations except in extremely wet soil, such as swamps. This does not, of course, mean that the tree grows equally well everywhere, for it undoubtedly prefers a well-drained, loamy sand, and there reaches its best development. Ideal conditions exist on the slopes and at the bottoms of the old glacial deposits so numerous all over the State.

The white pine grows either pure or in mixture with other species, but in the latter case the other trees should form a lower or under story about the pine, otherwise, the tree will not grow well, being too much shaded by the others. It is a mistake to believe that white pine is a shade-enduring tree, for, while some shade is beneficial in the early stages of growth, it is very harmful at later periods.

Reproduction is by seed, which is produced annually, but in much larger quantities at intervals of from five to six years,

called "seed years." The seeding process is described in detail elsewhere in this bulletin.

As regards size and rate of growth, white pine compares favorably with any eastern tree and far exceeds most of them in these respects, reaching merchantable size in about fifty years, as shown in the "Forest Mensuration of the White Pine in Massachusetts," published by the State Forester in 1908. If left to grow undisturbed, it reaches a size excelled only by trees of the Pacific coast, specimens having been recorded that exceeded 200 feet in height, with a diameter of 6 feet, while heights of 100 feet, with 3-foot diameters, are not uncommon.

The chief enemy of this tree, as of all others in this State, is fire, which, if it does not kill, so weakens it as to render it liable to attack by all kinds of insects and fungi. The white pine is especially susceptible when young, even a slight ground fire being quite sufficient to completely kill it. In this respect it resembles the chestnut.

Leading insect enemies are the pine weevil and the various bark borers, all of which are much less likely to cause trouble in healthy stands than in those weakened by other causes. The gypsy moth, while it will eat pines as well as everything else, is not apt to invade pure stands containing this species alone. The brown-tail and leopard moths do not eat pine.

It seems almost unnecessary to enumerate the uses of the tree, as they are so well known. Among them may be mentioned building timber of all kinds, laths, various kinds of cabinet material, interior finish, wooden ware, matches, flag poles, masts and boxes.

Red or Norway Pine (Pinus resinosa).

This tree, while common in southern Maine, is not so familiar to residents of Massachusetts, partly because it does not grow in pure stands, but only as scattered individuals, and partly because the difficulty of collecting the seed renders the cost of planting either seed or seedlings very high. The tree, however, is a very excellent species, and compares favorably with white pine in many respects.

It grows on the same kind of soil as the white pine, but will grow on dry ridges, where the white pine will not. It will not grow in swamps or in poorly drained soil.

It associates usually with white pine, growing in scattered groups throughout the stand. More rarely it is found in company with hardwoods, such as oaks and birches.

Red pine is a rather poor seeder, not beginning to bear until about twenty-five years old, and then giving only light crops at four or five year intervals. The seed will not germinate in thick grass or sod, and the seedlings require much light. A bare mineral soil containing some moisture is best. The percentage of germination is high.

In rate of growth red pine is more rapid than white, especially when young, though it is more short-lived in the long run. It reaches a diameter of 23 inches and a height of 80 to 90 feet in one hundred and twenty-five years, producing merchantable timber. Sixty years will produce good small stock.

No serious insect pests or fungous diseases attack this species, and it is remarkably free from rot. Light ground fires do not injure it so much as they do white pine, especially as the tree grows older.

The wood is used for general construction, bridge timbers, shipbuilding, car construction and flooring.

Pitch Pine (Pinus rigida).

This tree grows on dry sandy soils, and is especially suited to planting in such localities. When pure it forms very thin stands, owing to its extreme intolerance, and it must be above all other species in mixture, or it will die.

It is a prolific seeder, and succeeds well under the above conditions, and is also a fairly rapid grower, reaching at times a height of 80 feet and a diameter of 30 inches.

It is not subject to attack by insects or fungi, and is probably the most resistant to fire of any conifer in Massachusetts, surviving repeated burnings.

The wood is used largely for fuel, being brittle and not strong.

Scotch Pine (Pinus sylvestris).

This tree is the common pine of northern Europe, occupying there the same place that the white pine does in this country as a timber tree. Its growth, however, more closely resembles

our Norway, both in quality of lumber and in the kind of soil preferred by the tree.

It differs, however, in the fact that it grows well in dense pure stands rather than in mixture with other species, and also in that it seeds often and abundantly, and therefore costs much less to grow than red pine.

In common with the other pines, Scotch is not much subject to disease and insect attack, but is somewhat more sensitive to fire than red.

It is used for the same purposes as red pine.

Hemlock (Tsuga americana).

This tree, easily the most tolerant of the American conifers, prefers cold north and east slopes of the hillsides in the northern parts of the State. Because of its extreme tolerance, it will grow either with any other species, evergreen or hardwood, or in dense pure stands in all stages of growth.

The seeds are borne in very small cones, and are very light. Reproduction is good under favorable conditions of soil and location, and the tree frequently grows apparently out of bare rock, so thin is the soil.

Trees of this species often grow to a very large size, but such individuals are apt to be rotten and shaky. Other species will not grow under hemlock because of the dense shade cast by it.

The wood is being used more and more for building timber, as the supply of other species grows scarcer, and some lumber dealers prefer it to spruce for rough frame timbers. If care is not used in drying it is very likely to check.

Red Spruce (Picea rubra).

This tree is the timber spruce of Maine, and is now the most important species in that State in size of cut. It will grow in northern Massachusetts on the higher elevations, preferably in mixture with pine and hemlock.

It will grow in the shade of other trees for many years, and shows marked ability to start up and grow when suddenly exposed to the light.

Growth is not rapid, and large size is not reached by this

species; but good, straight timber is produced, which finds a ready market. The limbs do not drop off readily, however, and clear timber can therefore be grown only in dense stands.

The tree reproduces itself well when the leaf litter on the ground is not too thick, and the seedlings therefore start readily under the mature trees of the same species, forming a stand containing trees of all ages.

The principal enemy is the spruce bark beetle (*Dendroctonus piceaperda*).

The uses of the wood are well known; building timber, piano sounding boards, inside finish, clapboards, and in Maine pulp-wood, are among them.

Norway Spruce (Picea excelsa).

This is one of the principal timber trees of Europe, and is strongly recommended for planting in this country, possessing, as it does, all the advantages of the red with the added one of being a much more rapid grower.

2. NORTHERN HARDWOODS.

Rock Maple (Acer saccharum).

This tree, known also as the sugar maple, is one of the most important of our northern hardwoods, both for sugar and timber. It grows usually in mixture with beech, oaks, ashes, etc., as well as conifers, but may grow in pure stands.

Its chief silvicultural feature is its extreme tolerance, making it the most shade-bearing of all American hardwoods, with the possible exception of beech. A deep, moist soil is necessary for good growth.

Seed is produced almost every year, but full seed years occur only at intervals of from three to five years. The percentage of germination is rather low, but this is offset by the ability of the young trees to stand dense shade.

Growth is slow, but persists for a long time, the tree reaching a height of 70 or 80 feet and a diameter of 2 or 3 feet. The tree is not very wind-firm.

Rock maple is not very susceptible to injury by fire or fungi, though a good deal of damage is sometimes done by the forest

tent caterpillar, which strips the foliage from the tree and so reduces its vigor. Another enemy is the "saddled prominent" (*Heterocampa guttivitta*), which has caused a great deal of damage in Maine and New Hampshire, but is now being brought under control by natural enemies.

Beech (Fagus ferruginea).

This tree is conceded to be the most tolerant of all the hardwood species found in Massachusetts; that is, it will grow well beneath the most dense shade, provided the soil is suitable for germination, and not only this, but it requires shade in order to start at all. It grows best on rich, loamy soil, on cool slopes, in mixtures with other hardwoods, such as the oaks, chestnut and maple. It sometimes forms pure stands with here and there scattering pine and hemlock.

The nuts are so much liked by squirrels that reproduction is hindered by these animals.

The beech is a rather slow-growing tree, generally owing to the dense shade which surrounds it; but it reaches good size, both in height and diameter.

The principal enemy in Massachusetts may be said to be the "saddled prominent," previously mentioned, which prefers the leaves of this tree to all others, thus causing the woods to resemble winter in the height of the growing season.

The wood forms one of our most valuable hardwoods, and is used for tool handles, furniture, flooring and in turnery.

White Birch (Betula papyrifera).

This tree is to be rigidly distinguished from the grey birch (sometimes called "white") so common in this State. The latter species (*Betula populifolia*) is practically valueless for all purposes, fuel included, and must not be confused with the white, which forms a valuable timber tree.

White birch grows on northerly slopes, in mixture with other hardwoods, pine and hemlock. The seed is very light, favoring reproduction by the wind, and causing the propagation of the species over burned areas when there is enough soil moisture to support tree growth. The tree will not stand shade, being

very intolerant, and the seed will not germinate on a thick layer of humus, so that reproduction within the woods is unlikely.

A long, clear bole is developed by growth in the forest, the tree reaching a height of 70 to 80 feet in sixty to seventy-five years. It is a short-lived tree, seldom living over one hundred and twenty years when grown from seed; sprouts do not live over ninety years.

Its most serious enemy is fire, since it is not subject to attacks by insects, fungi or windfall.

The wood is used, to the practical exclusion of all others, in the manufacture of spools, shoe pegs, shoe shanks, and very largely for toothpicks, dowels, bobbins, shuttles and various toys and novelties.

Yellow Birch (Betula lutea).

This tree is quite commonly found in Massachusetts in mixture with evergreens and deciduous species, where it is distinguished by its yellow, shiny bark, usually of a tattered appearance.

It is a valuable species for ship building, furniture and wheel hubs, having a very fine, clear texture of grain.

It is mentioned in this list not because we desire to urge planting this species, but in order that owners may recognize it as a valuable tree, and not of the same class as the grey birch, which, of no value in itself, usually causes more or less injury to its neighbors by interfering with their proper development.

3. SOUTHERN HARDWOODS.

Chestnut (Castanea dentata).

This tree, like the oak, reaches its best condition on the lower slopes of hills, or in coves where the soil is rich, moist and fairly deep. It will grow, however, on a very thin soil, if it be loamy. It grows much more rapidly than the oaks, attaining saw log size in about fifty years. Under favorable conditions it will attain a height of 100 feet and a diameter of 3 or 4 feet. As a sprout its growth is remarkable, excelling that of any deciduous tree except poplar.

It bears a crop of seed each year, but the crop varies in abundance.

The tree is quite intolerant, but, as it grows more rapidly than the other hardwoods with which it associates, it has little trouble in getting all the light it wants.

The chestnut, in common with the hardwoods, is of course eaten by the gypsy moth, but it has few insect enemies peculiar to itself. It is, however, gravely affected by a fungus called the chestnut bark disease (*Diaporthe parasitica*), which has killed practically every chestnut tree within twenty miles of New York. The tree is severely injured by fire, on account of the lightness and inflammability of its bark.

The wood is light, stiff, strong, and very durable in contact with the soil. It is used for ties, poles, building material, posts, slack cooperage and furniture. The wood is distilled, and produces a tanning extract used in the place of tan bark. The cut of chestnut has increased nearly 100 per cent. in the past decade.

The Oaks, White, Red and Black.

For their best development our native oaks require a rich, moist soil, situated in cover or on the lower slopes of a hill. With the exception of the swamp white oak, they will not grow on wet land; and, on the other hand, they make a fair growth on the top of dry, exposed ridges.

They require considerable sunlight for their best development, but the black and red oaks will stand some shading. The white oak is quite intolerant.

The white oak bears seed nearly every year, but the trees of the black oak family require two years to mature the acorns.

The oak is a slow-growing tree, requiring at best seventy-five years to obtain a tree of saw log size. The black and red oak grow more rapidly than the white in early youth, but the white oak maintains its growth for a longer period, so that at the age of maturity there will be little to choose between them as to size.

Brown-tail and gypsy moths seem to be particularly fond of oaks, but, as they eat other species very readily, this preference is not of great importance. The "saddled prominent" (*Hetero-*

campa guttivitta), an insect now doing a large amount of damage in northern New England, is known to eat it at times. The oak is unusually free from borers and bark beetles, and is quite resistant to damage by ground fires.

Oak wood is heavy, hard, tough, close-grained and very durable. White oak has these qualities to a greater degree than the red and black. The wood is used extensively in ship building, tight cooperage, vehicle manufacture, farm implements, ties, interior finish and furniture. So great is the economic value of this wood that the available supply is being rapidly exhausted.

Red Maple (Acer rubrum).

This tree is partial to wet land, and is our typical swamp tree, growing pure or in company with ash, hornbeam and hemlock. Like other swamp-land trees, it is very tolerant of shade, although in this condition its growth is slow.

It bears an abundance of seed each spring.

Under forest conditions it seldom attains a height of more than 60 feet and a diameter of more than 15 inches. It grows quite rapidly when young, but slacks materially when about thirty years old.

It is not attacked so readily by gypsy and brown-tail moths as are most of the other hardwoods.

The wood is lighter, not as strong and more subject to decay than is hard maple, but is sometimes used as a substitute for it.

It is not a tree that is recommended for forest planting.

Shagbark Hickory (Hicoria ovata).

This tree is of increasing importance because of its increasing scarcity, due to the heavy demand for hickory wood, — a demand caused by its unrivalled good qualities for certain kinds of construction.

It is primarily a tree of fresh, fertile soils and rich situations along streams, and produces good wood in clay soil.

It is never found pure to any great extent, but always in mixture with other species, and, being very tolerant, will grow well in the shade of the others.

Seed is borne in a fairly prolific manner every two or three years, but the nuts are largely eaten by weevils and squirrels.

Growth is not very rapid, but is extremely persistent, the tree living to an age of two hundred to two hundred and twenty-five years, in full vigor. Timber trees are produced in about one hundred years.

The wood is used for vehicle construction, handles of axes, etc. It is the strongest of the hickories except pignut, and should be favored over that species except on dry soils and where there is no market for the nuts.

Black Locust (Robina pseudacacia).

The black locust is a more southern species, but will grow in Massachusetts, and is recommended where a quick-growing tree is desired. It demands plenty of light and a mineral soil, and produces its best wood at forty to fifty years, reaching only some 60 to 70 feet in height. The seed is borne in pods, and if left in them preserves its germinating power for several years. Seedlings grow best when raised in the nursery for one year.

The wood is heavy, exceedingly hard and strong, very durable in contact with the soil, and is used in ship building, turnery and construction. It is preferred for tree nails, and makes good railroad ties.

White Ash (Fraxinus americana).

This tree prefers to grow on rich, moist bottom lands, where it will be found mixed with elm, basswood, yellow birch and maple. It will grow in a wet swamp and equally on dry, exposed ridges, so that it may be said to be versatile in habit.

It is quite tolerant when young, but when too much shaded its diameter growth is very slow.

Some seed is produced each year, but abundantly only once in three years. It is quite easy to collect, and the tree is therefore one used quite extensively in forest planting.

The rate of growth is rapid when compared with that of most of the associated hardwoods, but it varies considerably according to conditions of moisture and situation. Post timber may be obtained from it in from fifteen to twenty years.

White ash is attacked by a number of fungous diseases, which injure the leaves and flowers, but not sufficiently to kill the trees. It has the distinction of being the only deciduous tree

which the gypsy moth does not attack, although there have been cases where this pest has attacked this tree when everything else was gone.

The wood is tough and elastic, and this, combined with its ability to take a good polish and to season without injury, makes it a timber of exceptional value for furniture, car vehicles, manufacture, interior woodwork, agricultural implements and tools.

Plantations will do best in a protected valley on a light loam.

No.....

Received.....



APPLICATION
FOR AN
EXAMINATION OF LANDS SUITABLE
FOR REFORESTATION

TO THE
MASSACHUSETTS STATE FORESTER,
6 BEACON STREET, BOSTON.

The State Forester is empowered, under chapter 478, Acts of 1908, to accept, on behalf of the Commonwealth, gifts of land to be held and managed for the purpose of experiment and illustration in forest management and for reforestation.

The owners of land acquired under this act, or their heirs and assigns, may redeem the land from the Commonwealth at any time within ten years, upon payment to the Commonwealth of the amount expended in improvements and maintenance; provided, however, that there shall be included in the deed of reconveyance a restriction requiring that in the future the cutting of trees on this land shall be in accordance with modern forestry methods.

"SECTION 8. The state forester shall re-plant or otherwise manage all land acquired by the Commonwealth and held by it under the provisions of this act, in such manner as will, in his judgment, produce the best forest growth both as to practical forestry results and protection of water supplies."

Upon receipt, this request will be placed on file, and you will be informed, in order of application, approximately when the examination can be made, and a mutual date can then be decided upon.

It is always more satisfactory to personally meet on the property the owner or party most interested. In this way a definite understanding can be had as to future undertakings.

When sending in this application, a brief description of the land will assist us.

With the above understanding, I desire to have an examination made of a tract or tracts of land of approximately.....acres, located in the town of.....county of.....State of Massachusetts.

Signed

Address

Date.....19 .

A STUDY
OF THE *Walter Mafford*
MASSACHUSETTS
WOOD-USING INDUSTRIES

BY HU MAXWELL, EXPERT

United States Forest Service

UNDER THE DIRECTION OF

PROF. F. W. RANE

State Forester, Commonwealth of Massachusetts

AND

H. S. SACKETT

In Charge of Wood Utilization, United States Forest Service



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INTRODUCTION.

The Bureau of the Census, in co-operation with the United States Forest Service, compiles and publishes statistics annually, showing the output of sawmills by States and for the whole country. The cut in Massachusetts in 1908 was 384,526,000 feet B. M., reported by 610 sawmills. This did not include pulpwood, tanbark, tanning extracts, cross-ties, telegraph and telephone poles, or cooperage and veneer stocks.

After lumber leaves the sawmill it serves many purposes. Some of it passes through no further process of manufacture, but goes into buildings with only the cutting and fitting which carpenters give it. Another part is further manufactured before it is used. Wood-working machines of many kinds change its form, and it is cut, joined and fitted by skilled labor, becoming, partly or wholly, a finished product, — boxes, frames, doors, sash, vehicles, boats, shuttles, spools, lasts, baskets, musical instruments, furniture, handles, toys, brushes and many more. This study has to do with that part of lumber only which undergoes further process of manufacture after it leaves the sawmill.

Heretofore, lumber has not been very carefully followed after it leaves the saw, to ascertain what becomes of it, what is made of it, and into what commodities it enters. In a general way it has been known that some of it is used in its rough form, and some passes through further process of manufacture. The present study of the wood-manufacturing industries of Massachusetts was undertaken to supply information concerning the lumber which is not used in its rough form. The work has been done in co-operation by the United States Forest Service and the State of Massachusetts. Industries which manufacture commodities wholly or partly of wood were asked to furnish data along their special lines, and this report is based on their replies, supplemented by independent investigations throughout the State.

Statistics thus collected and published are expected to be useful to both growers and manufacturers of wood. It is shown what part

of the total demand, and of the demand for each species, is met by forests and woodlots in the State, and what part is supplied from without. The kinds of wood demanded by the various industries are shown, together with the amount of each species used, the prices paid at the factory, and into what product each wood is manufactured. With this information before them, the woodlot owners who are looking to the future can determine what kinds of timber promise best returns, and can give preference to those kinds. Those who have timber or lumber to sell can form an intelligent opinion as to where the best market may be found for what they have to offer. On the other hand, the manufacturer who is in the market for woods of certain kinds will have the means to determine whether he can buy near home, or whether he must look beyond the State; and a study of average prices paid by others will show whether or not he has been buying on an equal footing with others. A closer acquaintance between buyer and seller, with a better understanding of what one has to sell and what the other wishes to buy, will be of mutual benefit.

A history of lumber operations and of past uses and markets in the State was not undertaken, though it would have brought out many interesting facts. It was deemed sufficient if present conditions were shown, thereby making it possible to formulate an intelligent policy for future operations.

MASSACHUSETTS WOOD-MANUFACTURING INDUSTRIES.

Manufacturers in Massachusetts convert approximately 550,000,000 feet of rough lumber a year into finished products. The total quantity of wood used annually in the State is not shown by these figures, — certainly not half of it, — but only that portion of it which, after it leaves the sawmills, is further worked by machinery, or, at least, by the expenditure of considerable labor upon it. The mere cutting off of beams, planks and boards to fit them in house frames, bridges or trestles, or the mortising or joining in rough construction, does not constitute sufficient manufacture to bring the product within the scope of this study. Neither are railroad ties, poles, shingles and clapboards included. No attempt has been made to ascertain how much wood of all kinds and for all purposes is used in this State, nor to show what the market value is when the products take their final form. Finished commodities shipped into the State ready for use are not included in the tables and totals which follow. This distinction excludes a great deal of planed and matched flooring, siding and interior finish, which is fully manufactured before it is shipped into Massachusetts. The same consideration excludes much furniture and many wheeled vehicles which come into the State ready to assemble, or partly assembled. Though sold in Massachusetts, they are not manufactured here.

A painstaking effort has been made to keep species separate. They have not been grouped as "oak," "pine," "hardwoods," etc., but as white oak, red oak, yellow oak, white pine, longleaf pine, black gum, red gum, etc. The identification and listing of species was perhaps not successful in all cases; and in other instances, where use is confined almost exclusively to one species, though the genus includes others, a common term, as "ash" or "maple," was deemed sufficient. In Table 1, which follows, all the kinds of wood reported are brought together, except a few for which no figures showing the amount used yearly could be procured. All the species, together with the uses reported for each, will be found in the part of this report dealing with uses by species, beginning on page 34. Fifty-four woods are listed in the following table: —

TABLE 1. — *Kinds of Wood used, Quantity of Each, with Total Cost, and the Per Cent. grown in the State and out.*

SPECIES.	Feet used B. M.	Cost at Factory.	Grown in Massa- chusetts. (Per Cent.).	Grown outside of Massachu- setts (Per Cent.).
White pine	296,787,000	\$5,061,821	44	56
Spruce	45,772,400	882,491	17	83
Hemlock	31,557,000	547,151	17	83
Maple	30,252,300	578,837	11	89
Longleaf pine	27,368,500	776,391	—	100
White oak	24,287,700	936,492	12	88
Fir	14,999,100	277,511	10	90
Yellow poplar	14,806,400	656,765	10	90
Chestnut	11,753,000	163,781	34	66
Beech	9,873,000	193,436	18	82
Sweet birch	9,846,400	227,244	20	80
White birch	5,665,000	93,766	28	72
Basswood	4,166,500	106,487	3	97
North Carolina pine	4,115,000	162,410	—	100
Ash	3,440,300	140,114	11	89
Elm	2,698,500	107,493	1	99
Mahogany	2,025,400	298,253	—	100
Hickory	1,564,500	112,060	5	95
Cypress	1,252,000	65,860	—	100
Pitch pine	887,000	16,605	83	17
White cedar	795,500	15,477	11	89
Yellow birch	757,000	16,352	8	92
Black walnut	743,100	73,452	1	99
Douglas fir	655,000	26,723	—	100
Cherry	611,250	26,639	1	99
Western cedar	603,500	24,245	—	100
Black gum	475,000	22,032	—	100
Red oak	398,000	14,548	20	80
Redwood	356,100	13,610	—	100
Norway pine	250,000	5,000	—	100
Cottonwood	137,000	5,178	—	100
Sugar pine	68,600	4,392	—	100
Red gum	45,000	2,825	—	100
Dogwood	40,000	7,000	—	100
Persimmon	40,000	7,000	—	100
English walnut	35,000	4,200	—	100
Teak	33,000	7,196	—	100
Red cedar	27,000	1,655	—	100
Butternut	25,000	1,800	—	100
Sycamore	21,000	1,047	—	100
Holly	20,000	2,000	—	100
Circassian walnut	15,000	1,620	—	100
Applewood	13,800	166	100	—
Loblolly pine	8,000	192	—	100
Hazelwood	8,000	496	—	100
Yellow oak	8,000	320	100	—
African walnut	6,000	720	—	100
English oak	3,370	367	—	100
Spanish cedar	1,500	300	—	100
Italian walnut	1,212	242	—	100
Hackmatack	1,000	40	—	100
Prima vera	300	75	—	100
Rosewood	300	225	—	100
Ebony	112	28	—	100
Total	549,319,644	\$11,692,130 ¹	30	70

¹ The average price per M. for all the wood reported was \$21.29.

It is evident that Massachusetts is still a white pine State. It has always been that. The original forests contained some of the finest white pine ever cut in America; but the virgin stand was felled long ago, and the second, third and perhaps the fourth growths are now being drawn upon. How well the demand is met is indicated

by the fact that the present cut of this wood greatly exceeds the combined cut of all others in the State. Manufacturers last year used 133,276,000 feet of home-grown white pine, and only 33,172,923 feet of all the other State-grown species, — 4 to 1 in favor of white pine. Yet Massachusetts is not now producing half the pine demanded by home factories. Fifty-six per cent. of the total quantity comes from other States, some of it from as far west as Michigan. Large areas of vigorous young growth are coming on, and, with better protection from fire than formerly, there is promise of substantial gain.

The State grows only two woods in sufficient amounts to supply its manufacturers, and these are little-used species, — yellow oak and applewood. Pitch pine makes the next nearest approach to supplying the home market, and falls 17 per cent. short. But this is not an important wood; rated by quantity, it is twentieth on the list.

The amount of black walnut reported is disappointing, and of the small quantity used the State grows only 1 per cent., — less than 8,000 feet. It was once a popular wood for furniture, but available statistics indicate that Massachusetts now puts more of it into brush backs than into furniture. Its principal uses now are for musical instruments and gun stocks.

INDUSTRIES.

The articles made wholly or partly of wood are so many that a complete list is practically impossible, but a general division into industries is practicable. It becomes necessary, however, to decide somewhat arbitrarily at times as to the divisions in which certain commodities belong, and under what industry a certain manufacturer should be placed. For example, the distinction between "finish" and "fixtures" is clear enough at times, and at times not; and the dividing line between other industries is occasionally obscure. It is necessary, however, if figures are to be presented and useful comparisons made, that the division of the whole into separate parts must be insisted upon.

In the present study the wood manufacturers of Massachusetts have been listed under twenty heads, the twentieth being "miscellaneous," which includes everything not clearly belonging elsewhere. Care was exercised to make the divisions as distinct as possible, but doubts as to the proper listing of a commodity were not always cleared away. Table 2 names the industries, and likewise shows the average

price which each paid for wood at the factory, and the comparative quantity used by each. The amount of lumber used by all was 549,319,644 feet, and the average price was \$21.29 per thousand. If these figures are borne in mind, the table will show at a glance which industries paid more and which less than the average, and the comparative amount of lumber used by each will likewise be shown.

TABLE 2. — *Wood-using Industries, Average Prices paid for Lumber at the Factories, and the Per Cent. which each Industry used of the Total Quantity.*

INDUSTRIES.	Average Price paid for Lumber at the Factory per 1,000 Feet B. M.	Apportionment of the Total Quantity of Lumber among the Industries (Approximate Per Cent.).
Boxes and crates	\$16 02	64.00
Furniture	28 36	8.68
Steam and electric cars	27 80	5.40
Musical instruments	35 71	5.00
Interior finish and stair work	34 15	3.78
Lasts and fillers	16 99	2.39
Cooperage and tanks	14 06	1.33
Shuttles, spools and bobbins	18 83	1.02
Ships and boats	50 51	.72
Refrigerators	35 93	.59
Horse vehicles	58 85	.56
Garden and farm implements	25 02	.40
Automobiles	60 79	.34
Whips	21 38	.33
Cabinets, and store and office fixtures	67 92	.29
Baskets	14 47	.27
Toys	14 92	.17
Handles	17 94	.14
Brushes	27 07	.12
Miscellaneous	23 73	4.47

BOXES AND CRATES.

In quantity of wood used and in total cost, boxes and crates head the list. These items, and others, will be fully set forth in Table 3. It is worthy of remark that the State demands 351,941,350 feet of lumber for boxes. This is seven times as much as any other wood-

manufacturing industry requires, and almost twice as much as all the others combined. It is clear that the making of boxes and crates is preëminently the leading business in the State among those who manufacture wood. Box makers paid four times as much for their raw material — considering wood as raw material when it reaches the factory — as was paid by any other of the listed industries. The nearest approach was by the furniture makers, both in amount of lumber used and the cost. Twenty-three woods are on the list of box materials. The manufactured product ranged from the grossest crates, such as serve for shipping marble slabs or nursery stock, to the finest sample cases for commercial travelers, and receptacles for confectionery, toilet articles and jewelry. The cheapest wood reported, averaged for the whole, was cottonwood, at \$9 a thousand, cut in Massachusetts and received as logs at the factory. The most costly was mahogany, at \$251 per thousand, — a higher average price than was reported by any other industry in the State. Only one wood more costly was reported by any industry, — rosewood, at \$750 per thousand, for pianos. It is therefore apparent that box makers supply a wide range of customers and send their wares to many markets.

One-third of the manufacturers of wood in the State make boxes. It is a side line with many, who thus utilize what otherwise would be waste. Others, whose chief business is in other lines, perhaps not directly connected with wood, make boxes and crates for shipping their own products. Less than 38 per cent. of the reported box material is grown in the State. The largest importation is of white pine, spruce next. If no outside lumber were obtainable, boxes alone would consume 94 per cent. of the State's whole lumber cut.

Though some very fine and costly boxes are made, the bulk of them are of cheap lumber. It generally reaches the factory as wane-edge, unplaned boards, with bark on the edges, due to sawing small logs through and through without slabbing the four sides. Some factories saw, plane and match box boards, making shooks of them, and selling them to the users, who nail them up, but operate no wood-working machinery. Others do all the work, from the log — perhaps from the tree on the stump — to the finished box. In some instances a factory makes boxes for one purpose only, perhaps shoe boxes; while others manufacture many sizes, shapes and kinds.

TABLE 3. — *Boxes and Crates.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	8,800	\$26 76	\$235 45	1,000	\$19 00	7,800	\$27 75
Applewood . .	13,800	12 00	165 60	13,800	12 00	-	-
Basswood . .	605,500	26 99	16,342 75	100,000	21 50	505,500	28 08
Sweet birch . .	27,800	53 00	1,473 40	-	-	27,800	53 00
Cherry . . .	5,000	26 80	134 00	4,000	16 00	1,000	70 00
Chestnut . .	2,362,000	16 10	38,021 00	782,000	16 36	1,580,000	15 96
White cedar . .	700,000	18 50	12,950 00	-	-	700,000	18 50
Cottonwood . .	22,000	9 00	198 00	22,000	9 00	-	-
Elm . . .	854,000	38 90	33,221 00	-	-	854,000	38 90
Fir . . .	14,879,700	18 28	272,398 57	1,461,400	18 08	13,436,300	18 31
Hemlock . .	27,394,000	17 31	474,207 50	4,278,500	17 01	23,115,500	17 37
Maple . . .	350,000	20 57	7,201 00	75,000	11 33	275,000	23 09
Mahogany . .	12,000	251 00	3,012 00	-	-	12,000	251 00
White oak . .	55,000	12 00	660 00	-	-	55,000	12 00
Red oak . .	56,000	40 00	2,240 00	-	-	56,000	40 00
White pine . .	263,443,700	16 85	4,439,163 95	121,855,600	15 90	141,588,100	17 66
Longleaf pine .	1,591,000	15 31	24,365 00	-	-	1,591,000	15 31
Pitch pine . .	600,000	15 93	9,560 00	448,000	16 33	152,000	14 76
North Carolina pine	251,000	19 57	4,911 00	-	-	251,000	19 57
Yellow poplar .	6,723,800	24 00	161,350 60	1,465,000	17 95	5,258,800	25 68
Spruce . . .	31,972,000	17 57	561,775 25	2,677,700	17 42	29,294,300	17 58
Sycamore . .	10,000	25 00	250 00	-	-	10,000	25 00
Walnut . . .	250	144 00	36 00	-	-	250	144 00
	351,941,350	\$16 02	\$5,637,872 12	133,273,000	\$16 01+	218,668,350	\$16 03

FURNITURE.

Furniture makers report the use of 23 woods, ranging in price from \$152.70, the average paid for their mahogany, to \$11.31 for hemlock. The average price for all, as shown in Table 4, was \$28.36. The State produced 20 per cent. of its furniture wood, and drew the balance from many parts of the world, the mahogany coming from Mexico, Central and South America, and different parts of Asia and Africa. The showing for mahogany is high not only for furniture, but in other industries. Massachusetts used about 5 per cent. of the mahogany imported into the United States in 1908, and paid approxi-

mately 14 per cent. of the total value of the imported wood. It appears from that fact that the grade bought by Massachusetts manufacturers was very much above the average.

Furniture makers paid for wood grown in the State an average price of \$20.64, and for that brought from without \$30.37. One-third of all was white oak, and Massachusetts supplied 11 per cent. of it, and 21 per cent. of the maple, 14 of the sweet birch, beech 16, chestnut 47. A large part of all the lumber used went to chair factories, but the exact ratio between that made into chairs and that used for other kinds of furniture can not be stated. The bulk of the chair wood was beech, sweet birch and maple.

TABLE 4. — *Furniture.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
White pine . . .	2,686,000	\$20 38+	\$54,735 00	1,840,000	\$18 30	846,000	\$24 89
White birch . . .	50,000	19 30	965 00	40,000	19 87	10,000	17 00
Maple	8,563,000	20 29	173,775 00	1,763,000	18 40	6,800,000	20 78
Ash	900,000	24 62	22,157 00	48,000	22 81	852,000	24 72
Sweet birch . . .	6,388,000	21 30	136,099 00	926,000	17 15	5,462,000	22 01
Spruce	555,000	16 38	9,094 00	195,000	15 42	360,000	16 63
Chestnut	4,849,000	24 51	118,846 00	2,284,500	24 56	2,564,500	24 46
White oak	16,722,500	34 59+	578,485 00	1,838,500	25 18	14,884,000	35 76
Yellow poplar . .	319,500	34 77+	11,110 00	—	—	319,500	34 77
Basswood	408,000	19 80	8,006 00	20,000	20 00	388,000	19 60
Beech	4,943,000	20 09	99,304 00	812,000	15 99	4,131,000	20 89
Mahogany	762,000	152 70	116,350 00	—	—	762,000	152 70
Black walnut . .	20,000	121 40	2,428 00	—	—	20,000	121 40
Hemlock	163,000	11 31	1,843 50	119,000	11 05	44,000	12 00
Black gum	61,000	43 47	2,652 00	—	—	61,000	43 47
Elm	348,000	31 49	10,906 00	—	—	348,000	31 49
Cherry	148,000	79 39	11,750 00	—	—	148,000	79 39
Sugar pine	100	100 00	10 00	—	—	100	100 00
Sycamore	1,200	78 33	94 00	—	—	1,200	78 33
Yellow birch . . .	250,000	24 00	6,000 00	—	—	250,000	24 00
African walnut . .	3,000	120 00	360 00	—	—	3,000	120 00
Hazelwood	2,000	80 00	160 00	—	—	2,000	80 00
Cypress	1,000	80 00	80 00	—	—	1,000	80 00
	48,143,300	\$28 36	\$1,365,209 50	9,886,000	\$20 64	38,257,300	\$30 37+

STEAM AND ELECTRIC CARS.

Table 5, presenting statistics of car manufacturing, shows that southern yellow pine greatly surpasses all other woods in quantity used and in value. The two species, the longleaf and the North Carolina, constitute 80 per cent. of the total and 78 per cent. of value. A distinction between longleaf and shortleaf pines is not always recognized after they are made into lumber. Manufacturers reported much more of the former than of the North Carolina species, but it is not improbable that a good deal of the latter appears in the lists as longleaf. Massachusetts grows less than 6 per cent. of its car timber, and four-fifths of this small amount is white oak. The cheapest timber reported by car builders was hemlock, averaging \$19, and only a small quantity was used. Mahogany was the most costly, and a comparatively large quantity was used. It is employed as finish for passenger coaches and electric cars. Sixteen species in all are listed, as the following table sets forth in detail:—

TABLE 5.—*Steam and Electric Cars.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	370,000	\$43 05	\$15,925 00	9,000	\$35 00	361,000	\$43 24
Basswood . .	29,000	30 00	870 00	9,000	30 00	20,000	30 00
Sweet birch . .	28,000	50 00	1,400 00	5,000	50 00	23,000	50 00
Maple . . .	17,000	29 90	508 00	5,000	20 00	12,000	34 00
Mahogany . .	185,000	144 32	26,700 00	—	—	185,000	144 32
White oak . .	2,176,000	33 73	73,397 50	141,000	30 67	2,035,000	34 43
Longleaf pine .	24,610,000	25 61	630,000 00	—	—	24,610,000	25 61
North Carolina pine	600,000	33 00	19,800 00	—	—	600,000	33 00
White pine . .	635,000	22 00	13,970 00	—	—	635,000	22 00
Spruce . . .	230,000	20 00	4,600 00	—	—	230,000	20 00
Yellow poplar .	517,000	60 00	31,020 00	—	—	517,000	60 00
Cherry . . .	13,000	125 00	1,625 00	—	—	13,000	125 00
Chestnut . .	7,000	22 00	154 00	—	—	7,000	22 00
Hemlock . . .	6,000	19 00	114 00	—	—	6,000	19 00
Norway pine . .	250,000	20 00	5,000 00	—	—	250,000	20 00
	29,673,000	\$27 80	\$825,083 50	169,000	\$30 91+	29,504,000	\$27 78

MUSICAL INSTRUMENTS.

The makers of musical instruments reported the use of 27 kinds of wood. The largest quantity went into pianos, but organs, including pipe organs, used the greatest number of woods. Twenty-two species grow in the United States, but only seven were supplied wholly or in part by Massachusetts, and they made less than 5 per cent. of the total. Seventy-four per cent. of all the black walnut reported by manufacturers in the State was used for musical instruments. None of the instrument walnut was State-grown. Yellow poplar is an important wood in this industry. Three woods were reported by makers of musical instruments and not reported by any others; they were red gum, prima vera and rosewood.

TABLE 6. — *Musical Instruments.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	91,000	\$43 27	\$3,938 00	10,000	\$11 00	81,000	\$47 26
Basswood . . .	40,000	32 38	1,295 00	40,000	32 38	—	—
Beech . . .	2,115,000	21 83	46,172 50	10,000	11 00	2,105,000	21 88
Sweet birch . . .	1,904,000	23 52	44,801 50	10,500	12 62	1,894,000	23 53
Butternut . . .	10,000	45 00	450 00	—	—	10,000	45 00
Cherry . . .	1,000	52 50	52 50	—	—	1,000	52 50
Chestnut . . .	3,838,000	24 23	93,012 00	300,000	23 33	3,538,000	24 31
Ebony . . .	12	250 00	3 00	—	—	12	250 00
Elm . . .	1,355,000	43 66	59,163 75	—	—	1,355,000	43 66
Fir . . .	101,400	50 41	5,112 00	—	—	101,400	51 41
Black gum . . .	320,000	44 13	14,120 00	—	—	320,000	44 13
Red gum . . .	45,000	62 78	2,825 00	—	—	45,000	62 78
Hazelwood . . .	6,000	56 00	336 00	—	—	6,000	56 00
Mahogany . . .	663,900	138 45	91,917 00	—	—	663,900	138 45
Maple . . .	4,101,800	28 33	116,201 10	248,000	24 64	3,853,800	28 57
White oak . . .	926,500	78 20	72,453 00	—	—	926,500	78 20
White pine . . .	3,935,000	27 86	109,775 00	694,500	30 26	3,240,500	27 39
North Carolina pine	602,500	35 10	21,150 00	—	—	602,500	35 10
Sugar pine . . .	33,500	73 34	2,457 00	—	—	33,500	73 34
Yellow poplar . . .	4,354,500	39 94	173,927 00	—	—	4,354,500	39 94

TABLE 6. — *Musical Instruments* — Concluded.

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Prima vera . .	300	\$250 00	\$75 00	—	—	300	\$250 00
Redwood . .	1,500	60 00	90 00	—	—	1,500	60 00
Rosewood . .	300	750 00	225 00	—	—	300	750 00
Spruce . .	2,367,700	24 45	57,885 60	—	—	2,367,700	24 45
Black walnut .	552,000	104 96	57,937 00	—	—	552,000	104 96
Circassian walnut .	12,000	100 00	1,200 00	—	—	12,000	100 00
Cottonwood . .	85,000	48 00	4,080 00	—	—	85,000	48 00
	27,463,412	\$35 71+	\$980,657 95	1,313,000	\$26 48+	26,150,412	\$36 17+

INTERIOR FINISH AND STAIR WORK.

Stair building is sometimes considered distinct from interior finish, but in this study it was not practicable to present separate statistics. The combined industries stand fifth in the list, on the basis of amount of lumber used. They head the list in the number of species. Twenty-eight appear, only three of which are foreign, and one of them, Italian walnut, appears in no other industry. Massachusetts supplied 20 per cent. of the wood reported, and 78 per cent. of it was white pine. This species constitutes 38 per cent. of all the lumber manufactured into interior finish and stair work. Some of the woods were of high grade, as indicated by the average prices shown in Table 7. This applies particularly to beech, mahogany, black walnut, cherry, sycamore and black gum. However, the average price paid for all the woods employed in this industry was considerably less than averages paid by makers of boats, horse vehicles, automobiles, cabinets and store and office fixtures.

The total number of feet shown in the table is clearly not the total used in the State for finish and stair work, — certainly not one-tenth of it. The table shows that part only which was manufactured in Massachusetts. This study, as was explained on a preceding page, was not concerned with products fully manufactured before they reached the State. The largest item in that class is flooring, of which a single firm reported the sale of 200,000,000 feet, all of which was manufactured ready for use before it came into Massachusetts, and

of course could not be included in this study. In several other instances, and for similar reasons, large amounts of finish, frames, sash and doors were excluded from consideration, though used by Massachusetts builders.

TABLE 7.—*Interior Finish and Stair Work.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
White pine . .	8,059,000	\$26 95	\$216,859 00	3,478,000	\$22 21	4,581,000	\$30 48
Yellow poplar . .	1,655,500	49 29	81,606 00	—	—	1,655,000	49 29
Sweet birch . .	838,600	36 65	30,735 00	500,500	32 02	338,100	43 51
North Carolina pine	2,628,500	40 73	107,064 00	—	—	2,628,500	40 73
Longleaf pine . .	962,000	36 07	34,696 00	—	—	962,000	36 07
Redwood . .	1,000	62 00	62 00	—	—	1,000	62 00
Cypress . .	1,165,000	52 25	60,888 00	—	—	1,165,000	52 25
Spruce . .	2,654,000	22 62	60,037 00	—	—	2,654,000	22 62
Hemlock . .	1,036,000	18 64	19,311 00	60,000	13 50	976,000	18 95
Ash . .	456,000	56 54	25,783 00	—	—	456,000	56 54
Mahogany . .	56,350	160 05	9,019 00	—	—	56,350	160 05
Black walnut . .	7,800	124 55	971 50	—	—	7,800	124 55
Redwood . .	1,000	80 00	80 00	—	—	1,000	80 00
Cherry . .	5,250	80 77	424 00	—	—	5,250	80 77
White oak . .	652,000	66 57	43,403 00	19,000	26 31	633,000	67 77
Sycamore . .	9,000	78 11	708 00	—	—	9,000	78 11
Maple . .	442,500	37 64	16,654 00	13,000	31 39	429,500	37 82
Black gum . .	4,000	65 00	260 00	—	—	4,000	65 00
Chestnut . .	338,000	21 94	7,416 00	310,000	20 13	28,000	42 00
White cedar . .	53,000	25 60	1,357 00	53,000	26 60	—	—
Basswood . .	501,000	33 21	16,637 00	—	—	510,000	33 21
Douglas fir . .	1,000	53 00	53 00	—	—	1,000	53 00
Sugar pine . .	35,000	55 00	1,925 00	—	—	35,000	55 00
English oak . .	1,370	210 00	287 70	—	—	1,370	210 00
Italian walnut . .	1,212	200 00	242 40	—	—	1,212	200 00
Beech . .	160,000	39 84	6,375 00	—	—	160,000	39 84
Red oak . .	1,000	30 00	30 00	1,000	30 00	—	—
White birch . .	75,000	19 00	1,425 00	—	—	75,000	19 00
	21,795,357	\$34 15	\$744,303 60	4,434,500	\$23 13	17,360,857	\$36 96+

LASTS AND FILLERS.

Table 8 presents statistics of the manufacture of lasts and fillers for the shoe trade. Fillers, which are also known as shoe forms or stretchers, are made of yellow poplar and basswood. The number is about 10 per cent. of the number of lasts. Only four woods were reported for this industry. Maple and beech supply the material for lasts, maple constituting 99 per cent. of the total. The most of it is cut in Michigan, with Pennsylvania as a second. The last industry stands sixth in the State for quantity of wood used, and it is worthy of note that the reports do not show that one foot of the wood was grown in Massachusetts. The manufactured product goes to every important country of the world where leather or rubber shoes are made. Lasts for rubber shoes and boots constitute a considerable trade, but they are not separately listed in the table. Only three lines of manufacture reported woods of lower average price than last makers use. These were toys, baskets and cooperage and tanks, statistics for which are shown respectively in Tables 9, 18 and 19. Last wood is selected with great care, is seasoned during two or more years, and is worked by machinery as true as skill can make it.

TABLE 8. — *Lasts and Fillers.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUTSIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Maple . . .	11,850,000	\$16 39	\$194,220 00	—	—	11,850,000	\$16 39
Basswood . .	982,000	23 51	23,085 00	—	—	892,000	23 51
Beech . . .	40,000	11 50	460 00	—	—	40,000	11 50
Yellow poplar .	160,000	22 50	3,600 00	—	—	160,000	22 50
	13,032,000	\$16 99	\$221,365 00	—	—	13,032,000	\$16 99

COOPERAGE AND TANKS.

Table 9 presents statistics of an industry which cannot be clearly defined, but its principal products are pails and buckets for confectionery and articles of that nature, tubs, keelers, churns, caddies, firkins, kits, tanks, vats and wooden receptacles of many kinds. No barrels or kegs for beer, molasses or spirituous liquors are included. The average price of the wood employed was lower than for any other

industry, being \$14.06 per thousand. White pine made 87 per cent. of it. Massachusetts furnished approximately 66 per cent. of all the wood reported. This was a percentage of home supply larger than for any other industry except toys (Table 19). Eleven species of wood were reported, and all are grown in Massachusetts except cypress, though the State seems to have supplied none of the white cedar. All the beech, white birch, chestnut, hemlock, maple and pitch pine were cut in the State, and 65 per cent. of the total amount used was home-grown. The average price of State-grown woods was higher than for those shipped in.

TABLE 9. — *Cooperage and Tanks.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Beech . . .	40,000	\$8 00	\$320 00	40,000	\$8 00	—	—
White birch . .	40,000	8 00	320 00	40,000	8 00	—	—
White cedar . .	25,000	38 00	950 00	—	—	25,000	\$38 00
Chestnut . . .	110,000	15 00	1,650 00	110,000	15 00	—	—
Cypress . . .	50,000	52 50	2,625 00	—	—	50,000	52 50
Hemlock . . .	50,000	10 00	500 00	50,000	10 00	—	—
Maple . . .	40,000	8 50	340 00	40,000	8 50	—	—
White oak . . .	90,000	18 33	1,650 00	40,000	18 75	50,000	18 00
Pitch pine . . .	277,000	25 00	6,925 00	277,000	25 00	—	—
White pine . . .	5,933,000	13 14	77,961 00	3,770,000	13 80	2,163,000	11 99
Spruce . . .	160,000	16 00	2,560 00	100,000	10 00	60,000	26 00
	6,815,000	\$14 06	\$95,801 00	4,467,000	\$14 29	2,348,000	\$13 64

SHUTTLES, SPOOLS AND BOBBINS.

Statistics of the manufacture of shuttles, spools and bobbins were compiled with difficulty, because much of the material is partly or wholly manufactured outside the State, and is received in small pieces difficult to measure and reduce to feet. Table 10 presents available data, but the total amount of wood used in the State is probably more than the table shows. The highest-priced material was dogwood, used exclusively for shuttles, and worth \$175 per thousand feet, — which was above the average for mahogany. It reaches the factory in blocks of many sizes. Tennessee and Kentucky supplied the most of it.

White birch was the principal spool wood, and Maine was the chief source of supply, but Massachusetts grew one-tenth. Eleven per cent. of all the wood employed in this industry grew in the State, and its average cost per thousand was 72 per cent. of the cost of that shipped from without. In every reported instance the price paid for outside wood in this industry was above the price of that grown in Massachusetts.

TABLE 10. — *Shuttles, Spools and Bobbins.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUTSIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Dogwood . .	40,000	\$175 00	\$7,000 00	—	—	40,000	\$175 00
Basswood . .	897,000	21 83	19,581 50	100,000	\$13 50	797,000	22 88
White birch . .	2,080,000	16 41	34,142 50	220,000	14 77	1,860,000	16 61
Beech . .	928,000	16 48	15,298 00	100,000	13 50	828,000	16 84
Maple . .	1,157,000	16 28	18,827 50	100,000	13 50	1,057,000	16 53
Yellow poplar .	102,000	13 73	1,400 00	100,000	13 50	2,000	25 00
Yellow birch .	412,000	23 07	9,504 00	—	—	412,000	23 07
	5,616,000	\$18 83	\$105,753 50	620,000	\$13 95	4,996,000	\$19 44

SHIPS AND BOATS.

Twenty-one woods are used in boat building. White pine heads the list, with 28 per cent. of all. Longleaf pine furnished nearly as much. Only five species were supplied in part by Massachusetts, and the amounts were very small, the aggregate being less than 2 per cent. of the total. The State once supplied white pine masts for the largest ships. The whole quantity of this species obtained in the State by boat builders was only 5,800 feet in 1908, which was scarcely the equivalent of two or three first-class masts. Four foreign woods were reported, — Spanish cedar, mahogany, English oak and teak. They made finish for yachts, canoes and steamboats. Teak was the highest priced and basswood the cheapest of the timbers reported for this industry. The average price of all was \$50.51, which was exceeded by only three industries. Loblolly pine, an abundant southern timber, was reported for this industry only. A large number of boats are in use in Massachusetts, and the comparatively small quantity of lumber reported for boat building indicates that the State is not supplying

the home market, and that considerable numbers of boats ready made are shipped in. Available statistics do not, however, confirm or disprove this assumption.

TABLE 11. — *Ships and Boats.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUTSIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	35,000	\$75 00	\$2,625 00	—	—	35,000	\$75 00
Basswood . .	365,000	17 00	6,205 00	—	—	365,000	17 00
Butternut . .	15,500	87 10	1,350 00	—	—	15,500	87 10
Red cedar . .	27,000	61 30	1,655 00	—	—	27,000	61 30
Oregon cedar .	3,500	70 00	245 00	—	—	3,500	70 00
White cedar . .	12,500	60 00	750 00	1,500	\$60 00	11,000	60 00
Spanish cedar .	1,500	200 00	300 00	—	—	1,500	200 00
Cypress . . .	24,500	68 16	1,670 00	—	—	24,500	68 16
Douglas fir . .	74,000	72 70	5,380 00	—	—	74,000	72 70
Elm	10,000	35 00	350 00	—	—	10,000	35 00
Maple	11,000	34 55	380 00	—	—	11,000	34 55
Mahogany . . .	44,000	151 48	6,670 00	—	—	44,000	151 48
English oak . .	2,000	40 00	80 00	—	—	2,000	40 00
White oak . . .	274,700	54 97	15,099 00	60,000	46 67	214,700	57 28
Red oak	5,000	90 00	450 00	—	—	5,000	90 00
White pine . . .	1,106,300	78 94	87,330 00	5,800	72 41	1,100,500	78 97
Longleaf pine .	1,071,500	36 82	39,453 25	—	—	1,071,500	36 82
Loblolly pine . .	8,000	24 00	192 00	—	—	8,000	24 00
North Carolina pine	15,000	35 00	525 00	—	—	15,000	35 00
Spruce	792,700	26 10	20,691 00	11,700	34 27	781,000	25 98
Teak	33,000	218 06	7,196 00	—	—	33,000	218 06
	3,931,700	\$50 51	\$198,596 25	81,000	\$46 80	3,850,700	\$50 59

REFRIGERATORS.

Massachusetts grows none of the timber which supplies its manufacturers of refrigerators. White pine exceeds in quantity all other woods combined in their construction. Yellow poplar furnishes the least, but its price is highest. Refrigerators are like furniture, in the fact that many sold in the State are made elsewhere. This does not apply to large sizes, constructed in place and not meant to be moved. The greater portion of the 3,240,000 feet of lumber reported is used for large refrigerators.

TABLE 12. — *Refrigerators.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Spruce . . .	145,000	\$27 24	\$3,950 00	—	—	145,000	\$27 24
Ash . . .	35,000	42 00	1,470 00	—	—	35,000	42 00
White oak . .	255,000	40 86	10,420 00	—	—	255,000	40 86
White pine . .	2,300,000	23 91	55,000 00	—	—	2,300,000	23 91
Sweet birch . .	220,000	18 00	3,960 00	—	—	220,000	18 00
Yellow poplar .	20,000	65 00	1,300 00	—	—	20,000	65 00
North Carolina pine	30,000	50 00	1,500 00	—	—	30,000	50 00
Red oak . . .	30,000	60 00	1,800 00	—	—	30,000	60 00
Beech . . .	155,000	18 00	2,790 00	—	—	155,000	18 00
Elm . . .	50,000	38 00	1,900 00	—	—	50,000	38 00
	3,240,000	\$35 93	\$84,090 00	—	—	3,240,000	\$35 93

HORSE VEHICLES.

Vehicles to be drawn by horses and those operated by power are distinct so far as manufacturing is concerned. The number of wagons, carts, drays, carriages and conveyances of that kind is apparently as large as ever, notwithstanding the increase in number of automobiles. Table 13 shows what was done in Massachusetts the past year in the manufacture of vehicles for horses. The number of vehicles is not shown, but the woods used are listed. These woods are generally high in price, the average being \$58.85 per thousand. Massachusetts furnishes only 14 per cent. of this, and the average price is \$25.98 lower than for imported timber. Except red oak, every wood from without cost more than the same species grown at home. Red oak was the same for both. A number of firms which formerly did their own manufacturing reported that they no longer do so, but buy vehicles ready to sell, or nearly ready, and now act as selling agents or merchants. They generally buy in the middle west. Others buy wooden parts dressed and fitted, and complete the work by putting the irons on and doing the painting. In this industry, as in many others, the manufacturing shows a tendency to move toward the source of supply for the raw material. A considerable part of the wood listed in Table 13 was used in repair work.

TABLE 13. — *Horse Vehicles.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	289,500	\$36 60	\$10,597 50	82,500	\$33 15	207,000	\$38 00
White oak . . .	1,364,500	53 86	73,500 00	308,500	40 66	1,056,000	57 72
Hickory . . .	969,500	79 96	77,525 00	6,500	64 61	963,000	80 07
White pine . . .	60,000	31 66	1,900 00	60,000	31 66	—	—
Yellow poplar . . .	74,000	86 08	6,370 00	6,000	70 00	68,000	87 50
Elm . . .	25,000	16 00	400 00	25,000	16 00	—	—
North Carolina pine	8,000	40 00	320 00	—	—	8,000	40 00
Sweet birch . . .	8,000	40 00	320 00	—	—	8,000	40 00
Maple . . .	6,000	35 00	210 00	—	—	6,000	35 00
Spruce . . .	10,000	48 00	480 00	—	—	10,000	48 00
Redwood . . .	3,000	7 00	210 00	—	—	3,000	70 00
Mahogany . . .	1,000	180 00	180 00	—	—	1,000	180 00
Yellow oak . . .	8,000	40 00	320 00	8,000	40 00	—	—
Chestnut . . .	3,000	40 00	120 00	3,000	40 00	—	—
Red oak . . .	250,000	35 00	8,750 00	50,000	35 00	200,000	35 00
	3,079,500	\$58 85	\$181,202 50	549,500	\$37 50	2,530,000	\$63 48

GARDEN AND FARM IMPLEMENTS.

Of the thirteen woods listed in Table 14, nine were supplied wholly or in part by Massachusetts, but what the State furnished was only 27 per cent. of the total. The average price paid at home was only 70 per cent. of that paid for imported lumber. It is of interest to note that one of the cheapest woods listed in this industry was black walnut, and that the whole supply came from Massachusetts. The quantity was not large, however, and that fact probably accounts for the low price. A small lot of home-grown yellow poplar was bought for \$13 a thousand, which was about one-fourth the usual price. This suggests a complaint sometimes made by woodlot owners and farmers who have a few trees. They say it is not always easy to sell small lots of logs, — three or four trees, perhaps, — because purchasers do not care to buy that way; they want carload lots. The owner probably cannot cut that many, and so he must sell at a low price, or not at all. Cases have been reported of farmers burning

logs that would have made good lumber. Mill men would make no offer on lots so small, though the general demand in the State for logs is far greater than the supply.

TABLE 14. — *Garden and Farm Implements.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUTSIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
White oak . . .	711,000	\$19 52	\$13,879 00	266,000	\$20 89	445,000	\$18 70
Maple . . .	270,000	17 28	4,665 00	50,000	13 00	220,000	18 25
Black walnut . .	8,000	16 50	132 00	8,000	16 50	—	—
Ash . . .	145,000	24 11	3,495 50	57,000	24 18	88,000	24 06
Spruce . . .	101,000	18 25	1,843 30	30,000	18 00	71,000	18 35
Chestnut . . .	50,000	15 00	750 00	50,000	15 00	—	—
White pine . . .	224,000	17 80	3,988 00	145,000	18 24	79,000	17 00
Hemlock . . .	108,000	18 00	1,944 00	—	—	108,000	18 00
Yellow poplar . .	4,600	39 56	182 00	2,000	13 00	2,600	60 00
Elm . . .	2,500	13 00	32 50	2,500	13 00	—	—
Longleaf pine . .	434,000	45 50	19,747 00	—	—	434,000	45 50
North Carolina pine	117,000	27 00	3,159 00	—	—	117,000	27 00
Black gum . . .	70,000	33 75	2,362 50	—	—	70,000	33 75
	2,245,100	\$25 02	\$56,179 80	610,500	\$19 17	1,634,600	\$27 24

AUTOMOBILES.

Manufacturers of automobiles predict that the use of wood in their industry will not increase in proportion to the increased output of the factories. Aluminum is taking the place of yellow poplar, mahogany, walnut and other expensive woods in the construction of bodies. The industry is so new that figures are not available to show the rate at which wood is being replaced by metal. Frames, however, are of wood, and apparently will continue to be. Of the 1,894,000 feet used, 1,279,000 feet were hickory and ash, and went into frames. Massachusetts-grown timber constituted 2 per cent. of quantity and less than 1 per cent. of value. Nine American woods and two foreign were listed in this industry.

TABLE 15. — *Automobiles.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Yellow poplar .	527,000	\$65 34+	\$34,435 00	—	—	527,000	\$65 34+
Ash . . .	778,000	57 36+	44,630 00	3,000	\$90 00	775,000	57 24
Mahogany . .	21,500	144 54	3,107 50	—	—	21,500	144 54
Cherry . . .	500	125 00	62 50	—	—	500	125 00
White pine . .	25,000	18 00	450 00	25,000	18 00	—	—
Spruce . . .	24,000	28 50	684 00	10,000	18 00	14,000	36 00
Hickory . . .	501,000	60 15	30,135 00	—	—	501,000	60 15
Basswood . . .	2,000	15 00	30 00	—	—	2,000	15 00
Black walnut .	10,000	110 00	1,100 00	—	—	10,000	110 00
Circassian walnut .	3,000	140 00	420 00	—	—	3,000	140 00
Sweet birch . .	2,000	40 00	80 00	2,000	40 00	—	—
	1,894,000	\$60 79	\$115,134 00	40,000	\$24 50	1,854,000	\$61 57

WHIPS.

Four woods only are listed as whip material in Table 16. Massachusetts grew 58 per cent. of all, but the average price for its share was little more than half the average paid for woods grown in other States. The measurement in feet of wood used by whip factories is difficult, because it reaches the factory in various forms and sizes. Some of it, too, is so far manufactured when it arrives as to exclude it from the scope of this study. The table which follows presents the available statistics for 1908:—

TABLE 16. — *Whips.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Beech . . .	521,000	\$19 33	\$10,070 00	251,000	\$13 42	270,000	\$24 81
Birch . . .	555,000	21 06	11,690 00	351,000	16 44	204,000	30 00
Maple . . .	733,000	22 13	16,225 00	458,000	17 41	275,000	30 00
Hickory . . .	18,000	60 00	1,080 00	—	—	18,000	60 00
	1,827,000	\$21 33	\$39,065 00	1,060,000	\$16 15	767,000	28 62+

CABINETS, AND STORE AND OFFICE FIXTURES.

The manufacturers of cabinets and of fixtures for stores and offices paid a higher average price for their lumber than was paid by any other wood-using industry in the State. The cheapest reported for this industry was hemlock, and its average was \$25. The average for mahogany was \$149.05. Much high-grade white oak, basswood and maple were reported. The dividing line between cabinets and fixtures is frequently difficult to define, and no attempt to do so has been made here. Of the lumber used, the State grew 10 per cent., but it received little more than 5 per cent. of the total price. For three of the woods, however, the State-grown product commanded higher prices than the same species grown elsewhere. These woods were chestnut, white oak and yellow poplar.

TABLE 17. — *Cabinets, and Store and Office Fixtures.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash	22,000	\$50 00	\$1,100 00	-	-	22,000	\$50 00
Basswood	186,000	58 49	10,880 00	-	-	186,000	58 49
Sweet birch	64,000	27 81	1,780 00	-	-	64,000	27 81
Cherry	47,000	41 17	1,935 00	-	-	47,000	41 17
Chestnut	50,000	35 40	1,770 00	10,000	\$65 00	40,000	28 00
Cottonwood	30,000	30 00	900 00	-	-	30,000	30 00
Elm	27,000	32 78	885 00	-	-	27,000	32 78
Hemlock	3,000	25 00	75 00	-	-	3,000	25 00
Mahogany	262,000	149 05	39,050 00	-	-	262,000	149 05
Maple	20,000	47 50	950 00	5,000	20 00	15,000	56 67
White oak	379,000	80 18	30,390 00	3,000	95 00	376,000	80 06
White pine	260,000	34 22	8,996 00	138,000	32 78	122,000	35 84
Yellow poplar	131,000	53 24	6,975 00	6,000	75 00	125,000	52 20
Spruce	105,000	20 38	2,140 00	-	-	105,000	20 38
	1,586,000	\$67 92	\$107,726 00	162,000	\$37 25	1,424,000	\$71 41

BASKETS.

Next after the woods used for cooperage and tanks, presented in Table 9, basket makers paid the lowest average price for their lumber. Much of it came to them as logs, and they did all the manufacturing. In other cases it was partly manufactured when it reached them. In this industry the average price for home-grown material was lower than for the imported, but the State furnished less than one-fourth of the total.

TABLE 18. — *Baskets.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	264,000	\$22 61+	\$5,971 00	138,000	\$21 67	126,000	\$23 66
Beech . . .	310,000	10 32+	3,200 00	10,000	20 00	300,000	10 00
White birch . . .	320,000	10 62+	3,400 00	20,000	20 00	300,000	10 00
Elm . . .	25,000	17 00	425 00	25,000	17 00	—	—
Maple . . .	379,000	10 52+	3,990 00	20,000	20 00	359,000	10 00
Red oak . . .	40,000	23 89	955 00	13,333	23 89	26,667	23 89
White oak . . .	130,000	24 61+	3,200 00	125,000	23 00	5,000	65 00
Rattan . . .	—	—	—	—	—	—	—
Willow . . .	—	—	—	—	—	—	—
	1,468,000	\$14 47	\$21,141 00	351,333	\$21 67	1,116,667	\$12 11

TOYS.

Massachusetts grows 77 per cent. of the wood worked in the toy factories of the State. A proportion so great of home-grown wood is not found in any other industry embraced in this study. The average price of the home-grown timber was 8 per cent. higher than for that grown elsewhere. Among the articles listed as toys are sleds, wagons, barrows, hobby horses, swings, games, menageries, villages, furniture, railroads and equipments, soldiers and small articles of many kinds.

TABLE 19. — *Toys.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Chestnut . . .	158,000	\$13 14	\$2,076 00	158,000	\$13 14	—	—
Hemlock . . .	190,000	13 00	2,470 00	—	—	190,000	\$13 00
Red oak . . .	16,000	20 00	320 00	16,000	20 00	—	—
Cherry . . .	2,000	30 00	60 00	—	—	2,000	30 00
Maple . . .	6,000	13 50	81 00	6,000	13 50	—	—
White birch . . .	256,000	14 97	3,831 00	256,000	14 97	—	—
Basswood . . .	30,500	19 93	608 00	10,500	16 00	20,000	22 00
Yellow poplar . . .	12,000	16 00	192 00	12,000	16 00	—	—
Beech . . .	193,000	15 00	2,895 00	193,000	15 00	—	—
White oak . . .	20,000	20 00	400 00	20,000	20 00	—	—
White pine . . .	50,000	20 00	1,000 00	50,000	20 00	—	—
	933,500	\$14 92	\$13,933 00	721,500	\$15 19+	212,000	\$14 01

HANDLES.

The handles represented by Table 20 are chiefly for buckets, packages, boxes, knives, shovels, tools and articles which do not require tough woods. Ax and hammer handles are of another kind. They account for the 25,000 feet of hickory listed in the table. Massachusetts grew all the hickory, and its price was higher than that of any other wood. Cherry was supplied wholly by the State, but its price was lowest. As in the case of toys, the average price of State-grown wood was above that of the imported lumber.

TABLE 20. — *Handles.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	5,500	\$29 00	\$159 50	5,500	\$29 00	—	—
Beech . . .	175,000	15 69	2,745 00	105,000	18 48	70,000	\$11 50
White birch . .	292,000	19 71	5,755 00	82,000	17 68	210,000	20 50
Cherry . . .	40,000	13 63	545 00	40,000	13 63	—	—
Hickory . . .	25,000	45 00	1,125 00	25,000	45 00	—	—
Maple . . .	212,000	14 60	3,095 00	142,000	16 13	70,000	11 50
White oak . . .	21,000	18 86	396 00	21,000	18 86	—	—
	770,500	\$17 94	\$13,820 50	420,500	\$18 80	350,000	\$16 90

BRUSHES.

The manufacture of brushes calls for a variety of woods, ranging in price from beech at \$10.53 per thousand feet to ebony at \$250. All the holly reported for the State was taken by the brush makers. It grew in North Carolina. It is worked into backs and handles for toilet brushes. The same use is made of rosewood, mahogany, black walnut and ebony. Cheaper woods serve as backs and handles of clothes brushes, blacking brushes, scrub brushes and others of similar kind. The purpose was to include under "Handles" (Table 20) all woods made into handles, as separate from the article as a whole; but it is probable that some of the woods listed under "Brushes" (Table 21) was made into handles for paint, varnish, whitewash and shaving brushes. The average price of home-grown woods was 30 per cent. under the average for outside material.

TABLE 21. — *Brushes.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
White birch . . .	393,000	\$18 58	\$7,304 00	115,000	\$11 56	278,000	\$21 52
Ebony . . .	100	250 00	25 00	—	—	100	250 00
Yellow poplar . . .	5,000	48 00	240 00	—	—	5,000	48 00
Black walnut . . .	25,000	78 00	1,950 00	—	—	25,000	78 00
Maple . . .	80,000	12 87	1,030 00	60,000	10 50	20,000	20 00
Holly . . .	20,000	100 00	2,000 00	—	—	20,000	100 00
Rosewood . . .	10,000	150 00	1,500 00	—	—	10,000	150 00
Mahogany . . .	20,000	100 00	2,000 00	—	—	20,000	100 00
Beech . . .	55,000	10 53	580 00	55,000	10 53	—	—
Yellow birch . . .	40,000	11 00	440 00	40,000	11 00	10,000	75 00
Ash . . .	10,000	75 00	750 00	—	—	—	—
	658,100	\$27 07	\$17,819 00	270,000	\$11 28	388,110	\$38 07

MISCELLANEOUS.

Table 22 is made up of odds and ends which could not properly be listed under any of the special industries. The articles from which the table was compiled were usually small, but the aggregate reached nearly 25,000,000 feet, or more than 4 per cent. of all the wood reported by the manufacturers of the State.

TABLE 22. — *Miscellaneous.*

SPECIES.	Quantity used annually (Feet B.M.).	Average Cost at Factory per M (f. o. b.).	Total Cost at Factory (f. o. b.).	GROWN IN MASSACHUSETTS.		GROWN OUT- SIDE MASSACHUSETTS.	
				Feet.	Average Cost per M (f. o. b.).	Feet.	Average Cost per M (f. o. b.).
Ash . . .	30,500	\$33 11	\$1,010 00	15,000	\$20 00	15,500	\$45 81
Basswood . . .	90,000	32 57	2,947 50	—	—	90,500	32 57
Beech . . .	238,000	13 56	3,228 00	238,000	13 56	—	—
White birch . . .	1,959,000	20 65	31,372 00	849,000	15 47	1,110,000	27 22
Sweet birch . . .	18,500	43 51	805 00	—	—	18,500	43 51
Yellow birch . . .	55,000	7 50	412 50	55,000	7 50	—	—
Western cedar . . .	600,000	40 00	24,000 00	—	—	600,000	40 00
White cedar . . .	30,000	14 00	420 00	33,000	14 00	—	—
Cherry . . .	1,200	42 50	51 00	1,000	25 00	200	130 00
Chestnut . . .	98,000	16 49	1,616 00	98,000	16 49	—	—
Cypress . . .	12,500	54 16	677 00	—	—	12,500	54 16
Douglas fir . . .	580,000	36 71	21,290 00	—	—	580,000	36 71
Elm . . .	7,000	30 00	210 00	—	—	7,000	30 00
Black gum . . .	100,000	50 00	5,000 00	—	—	100,000	50 00
Hemlock . . .	2,607,000	17 91	46,680 00	938,000	17 73	1,669,000	18 00
Hickory . . .	51,000	43 04	2,195 00	42,000	35 12	9,000	80 00
Mahogany . . .	1,650	150 00	247 50	—	—	1,650	150 00
Maple . . .	1,014,000	25 67	26,024 50	463,000	18 90	551,000	31 35
White oak . . .	510,500	55 90	28,538 00	110,000	12 95	400,500	67 70
White pine . . .	9,070,000	21 04	190,793 00	3,215,000	17 98	5,855,000	22 71
North Carolina pine	131,000	32 83	4,301 00	—	—	131,000	32 83
Pitch pine . . .	10,000	12 00	120 00	10,000	12 00	—	—
Yellow poplar . . .	210,000	43 83	9,205 00	—	—	210,000	43 83
Redwood . . .	350,600	37 79	13,248 00	—	—	350,600	37 79
Spruce . . .	6,656,000	23 55	156,751 00	1,860,000	21 36	4,796,000	24 40
Walnut . . .	120,050	75 03	9,008 00	—	—	120,050	75 03
English walnut . . .	35,000	120 00	4,200 00	—	—	35,000	120 00
	24,587,000	\$23 73	\$583,450 00	7,933,000	\$18 29	16,663,000	\$26 31

WOOD MANUFACTURERS.

Below is a list of Massachusetts manufacturers who supplied data on which this report is based. The names are grouped by industries. If a name appears under more than one industry, it indicates that the firm manufactures more than one commodity. Occasionally, for example, a firm makes its own shipping boxes, though its principal business is in other lines, and it is listed under both industries.

AUTOMOBILES.

S. R. Bailey & Co.	Boston
The Biddle & Smart Co.	Amesbury
Briggs Carriage Co.	Amesbury
Currier Cameron Co.	Amesbury
James N. Leitch & Co.	Amesbury
Quinsler & Co.	Boston
Sargent & Ham Co.	Boston
Chauncey, Thomas & Co.	Boston
Archibald Wheel Co.	Lawrence
Bartlett, Stevenson & Co.	Leominster
J. B. Judkins Co.	Merrimac
C. S. Pease & Sons	Merrimac
Knox Automobile Co.	Springfield

BASKETS.

M. E. Ballou & Sons	Becket
Baillie Basket Co.	Boston
D. S. Bridgman	Northampton
Williams Mfg. Co.	Northampton

BOATS.

The Atlantic Co.	Amesbury
D. D. Kelly & Son	Boston
George Lawley & Son	Boston
Rood Bros.	Fall River
Union Spar Co.	Gloucester
Stearns & McKay	Marblehead
H. Manley Crosby	Osterville
Fore River Shipbuilding Co.	Quincy
The Baker Yacht Basin	Quincy
E. H. Brown	Taunton

BOXES, CASES AND CRATES.

Blanchard & Gould	Acton
Acushnet Saw Mills Co.	Acushnet
Henry W. Cushman Co.	Acushnet
George W. Bryant	Amesbury
L. W. Love	Amesbury
N. E. Angus	Amherst
William O. Loveland	Ashby
The Diamond Match Co.	Athol
Smith & Rice Co.	Barre
George H. Allen	Beverly
A. W. Copp & Co.	Beverly
American Box & Lumber Co.	Boston
Dexter Box, Shook & Lumber Co.	Beverly

BOXES, CASES, AND CRATES — CON.

Frost Box Co.	Beverly
A. Ceppi & Co.	Boston
Conant Bros. Co.	Boston
A. H. Davenport Co.	Boston
F. C. & E. B. Gammons	Bridgewater
E. L. Bonney	Brockton
Mackie Bros. Co.	Brockton
F. L. Woodbridge,	Brockton
Doten Duntun Desk Co.	Cambridge
National Casket Co.	Cambridge
George G. Page Box Co.	Cambridge
A. B. Holden	Caryville
Frank B. Ford	Charlemont
Putnam Bros.	Charlton
Atwood & McManus	Chelsea
Parsons Mfg. Co.	Chelsea
Belcher & Taylor Agr. Tool Co.	Chicopee Falls
J. Stevens Arms & Tool Co.	Chicopee Falls
F. W. Purrington	Colrain
Cadwell & Glazier	Cooleyville
Flansburgh & Hardiman	Dalton
Crane & Co.	Dalton
F. J. Derry	Danvers
Woodman Bros. & Ross	Danvers
National Casket Co.	E. Cambridge
Joseph Lunan & Sons	Fall River
Isaac Varney & Sons	Fall River
Lynde Bros. Box Co.	Farley
Webber Lumber Co.	Fitchburg
Charles W. Welder	Fitchburg
E. S. Cook	Franklin
O. F. Metcalf & Sons	Franklin
F. E. & H. E. Chase	Freetown
Collier Keyworth Co.	Gardner
Perkins Box Co.	Gloucester
George A. Stevens	Gt. Barrington
New England Box Co.	Greenfield
Charles R. Field Mfg. Co.	Greenfield
Robert Darhurst	Halifax
E. H. Vaughan	Halifax
W. S. Simmons	Hanover
John Foster Co.	Hanson
O. S. Currier & Son	Haverhill
Haverhill Box Co.	Haverhill
C. H. Hayes Corp.	Haverhill
Hazen L. Foss	Haverhill
Island Park Box Co.	Haverhill

BOXES, CASES, AND CRATES — CON.

Doane & Williams . . .	Holyoke
Green Mountain Lumber Co. . .	Holyoke
Holyoke Box & Lumber Co. . .	Holyoke
C. J. Sawyer . . .	Hudson
N. G. Tripp . . .	Hudson
A. F. Purce . . .	Huntington
H. E. Stanton . . .	Huntington
Williams & Bridges Co. . .	Hopkinton
Ipswich Mills . . .	Ipswich
Hook & Hastings Co. . .	Kendal Green
George W. Dinsmoor . . .	Lawrence
Weld Bobbin & Spool Co. . .	Lawrence
Whitney Reed Chair Co. . .	Leominster
Beaman, Marvell & Co. . .	Leverett
Richardson Piano Case Co. . .	Leominster
Otis Allen & Sons Co. . .	Lowell
A. L. Brooks & Co. . .	Lowell
George L. Cady & Sons . . .	Lowell
Frank G. Cummings . . .	Lowell
T. W. De Long & Co. . .	Lowell
James A. Thompson . . .	Lowell
Crossman Box Co. . .	Lynn
Littlefield & Plummer Corpn. . .	Lynn
John Owens & Co. . .	Lynn
A. G. Potter . . .	Lynn
Samuel E. Vaughan . . .	Malden
Geo. L. Metcalf Wood & Paper Box Co. . .	Marblehead
Howe Lumber Co. . .	Marlborough
H. H. Oakman . . .	Marshfield
Bolles Bros. . .	Mattapoissett
T. C. Tinkham . . .	Mattapoissett
Edwin V. Mitchell Co. . .	Medfield
M. A. Ritchie . . .	Medfield
Medway Box Co. . .	Medway
A. T. Savery . . .	Middleborough
S. A. Eastman Co. . .	Milford
C. J. Billings & Sons . . .	Montague
L. P. Churchill Co. . .	Myricks
Natick Box Co. . .	Natick
D. S. Bridgman . . .	Northampton
Henry W. Warner . . .	Northampton
T. M. Cole . . .	No. Carver
William P. Proctor Co. . .	No. Chelmsford
L. S. Crafte . . .	No. Hatfield
Bullard & Sons . . .	No. New Salem
Gilbert H. West . . .	No. Pembroke
A. H. Sweet & Son . . .	Norton
W. D. Turner . . .	Norwell
The New Home Sewing Machine Co. . .	Orange
Chaffee Bros. Co. . .	Oxford
Lemuel Lefurgey . . .	Pembroke
North Dana Box Co. . .	Prescott
Paper, Lumber & Box Co. . .	Princeton
Myron F. Chickering . . .	Raynham
Otis P. Symonds & Sons . . .	Reading
Judah Hathaway . . .	Rochester
Alden Rounseville . . .	Rochester
C. N. Atwood & Son . . .	Rock
Gideon Studley . . .	Rockland
Amos C. Maynard . . .	Savoy

BOXES, CASES, AND CRATES — CON.

Sharon Box Factory . . .	Sharon
G. M. Ballou . . .	Shirley
The Horton & Hubbard Mfg. Co. . .	Somerville
Charles Hyde . . .	Southbridge
United States Spring Bed Co. . .	Springfield
F. M. West Box Co. . .	Springfield
Charles R. Richmond . . .	Taunton
Conrad H. Gale . . .	Tully
A. A. Flint . . .	Tyngsborough
Heywood Bros. & Wakefield Co. . .	Wakefield
E. L. Needham . . .	Wales
Ware Lumber Co. . .	Ware
G. M. Wheeler & Co. . .	Warwick
Cochituate Box Co. . .	Wayland
J. D. Putnam Son Co. . .	Webster
Blanchard & Gould . . .	W. Acton
Bartlett Box & Lumber Co. . .	Westborough
H. E. Lowe . . .	W. Boylston
S. A. Healy & Sons . . .	W. Chesterfield
W. J. McCarthy . . .	Westfield
Edwin B. Hedges . . .	Westfield
New England Whip Co. . .	Westfield
Lot Phillips Co. . .	W. Hanover
J. C. Goodridge . . .	Westminster
Upton Mfg. Co. . .	W. Acton
Reuben Loud & Sons . . .	Weymouth
Atwood Bros. . .	Whitman
G. M. Bradford . . .	Williamsburg
Williams & Bridges Co. . .	Worcester
Baker Box Co. . .	Worcester
W. D. Smith . . .	Wrentham

BRUSHES.

A. V. Stevens . . .	Cummington
Charles H. Ball . . .	E. Windsor
Florence Mfg. Co. . .	Florence
Willis H. Bean . . .	Lowell
Samuel E. Jordan Brush Co. . .	Malden
Florence Mfg. Co. . .	Northampton

BUILDERS' FINISH.

Clinton W. Schwamb & Co. . .	Arlington
N. Sarsfield . . .	Ashburnham
H. M. Peckham . . .	Athol
Arthur F. Tyler Co. . .	Athol
Smith & Rice Co. . .	Barre
Dexter Box, Shook & Lumber Co. . .	Beverly
John R. Atkins . . .	Boston
Boston Floor Co. . .	Boston
George H. Carter . . .	Boston
A. Ceppi & Co. . .	Boston
Louis Cohen & Co. . .	Boston
Charles A. Freeman Mfg. Co. . .	Boston
Graham & Cameron . . .	Boston
Irving & Casson . . .	Boston
A. E. Jones & Co. . .	Boston
P. W. Merrill Co. . .	Boston
Perkins Woodworking Co. . .	Boston
Dean-Penney Company . . .	Brockton

BUILDERS' FINISH — CON.

Hayward Screen Mfg. Co.	Brockton
Henderson Bros.	Cambridge
John Quinn & Son.	Cambridge
W. M. Pratt	Charlemont
E. R. Marshall	Chelmsford
Webber Lumber Co.	Fitchburg
K. L. Haskins	Greenfield
N. S. Cole & Sons	Haverhill
Messenger Wood Works	Haverhill
F. P. Stanton	Huntington
Doane & Williams	Holyoke
Robertson & Larkin	Hudson
S. F. Canney	Ipswich
William H. Bean	Lowell
J. B. Goodwin	Lowell
W. E. Hatch	Lowell
W. C. Miles & Co.	Medford
C. W. Maxim	Middleborough
A. W. Allen Co.	New Bedford
Greene & Wood	New Bedford
Tripp & Thorpe	New Bedford
L. R. Washburn & Son	New Bedford
Edward Perkins Lumber Co.	Newburyport
John E. Fales	Norfolk
S. B. Dibble Lumber Co.	No. Adams
William P. Proctor Co.	No. Chelmsford
Patten & Bond	Palmer
E. J. Faxon	Salem
Milton P. Locke & Son	Salem
J. A. Richmond & Sons	Shelburne Falls
George N. Gates	Shrewsbury
Springfield Lumber Co.	Springfield
The Ide Lumber Co.	Southbridge
J. K. & B. Sears & Co.	So. Hyannis
Lawrence M. Yale	Stockbridge
P. H. Pickens	Taunton
P. Jacobus	Turners Falls
Bartlett Box & Lumber Co.	Westborough
J. W. Bishop Co.	Worcester
Henry Brannon	Worcester
L. C. Clark Co.	Worcester
Flexible Door & Shutter Co.	Worcester
Hatch & Barnes	Worcester
J. W. Loring & Son	Worcester

CABINETS AND STORE AND OFFICE FIXTURES.

C. H. Bangs Druggist Fix- ture Co.	Boston
Eastern Showcase Co.	Boston
Charles P. Whittle Mfg. Co.	Boston
Doten Dunton Desk Co.	Cambridge
Library Bureau	Cambridge
A. W. Allen Co.	New Bedford
L. R. Washburn	New Bedford
E. W. Coffin	Worcester
J. W. Loring & Son	Worcester

COOPERAGE AND TANKS.

L. E. Flint	Ashby
New England Tank and Tower Co.	Boston
A. Bachelder & Co.	Lowell
T. M. Cole	No. Carver
S. W. Farrar & Son	Royalston

COOPERAGE AND TANKS — CON.

George A. Thayer	Spruce Corner
Charles R. Richmond	Taunton
B. & A. D. Fessenden Co.	Townsend
George P. Morse	W. Wareham
Wm. Brown & Son	Winchendon
M. H. Parks Co.	Winchendon

FURNITURE.

William O. Loveland	Ashby
Albert M. Wilder	Ashby
L. Morse & Sons	Athol
Smith, Day & Co.	Baldwinville
Waite Chair Co.	Baldwinville
Smith & Rice Co.	Barre
Oliver L. Briggs	Boston
J. E. Came Co.	Boston
A. H. Davenport Co.	Boston
Paine Furniture Co.	Boston
Irving & Casson	Boston
Shales & May	Boston
Allen Chair Co.	Concord Junction
Cadwell & Glazier	Cooleyville
T. T. Greenwood	E. Templeton
George W. Travers Co.	E. Templeton
Washburn & Haywood Chair Co.	Erving
Haywood Bros. & Wakefield Co.	Gardner
S. Bent & Bro.	Gardner
Brown Bros. Co.	Gardner
Collier Keyworth Co.	Gardner
Conant Ball & Co.	Gardner
P. Derby & Co.	Gardner
J. A. Dickerman	Gardner
Greenwood Bros. & Co.	Gardner
Kelly Bros.	Gardner
E. H. Mahoney Chair Co.	Gardner
Nichols & Stone Co.	Gardner
S. K. Pierce & Son	Gardner
L. B. Ramsdell Co.	Gardner
Charles R. Field Mfg. Co.	Greenfield
Merriam Hall & Co.	Leominster
Whitney Reed Chair Co.	Leominster
French & Heald Co.	Milford
H. E. Cummins	No. Brookfield
J. N. Crowe & Co.	Salem
Brown & Simonds Co.	Somerville
Derby Desk Co.	Somerville
Alfred H. Whitney	So. Ashburnham
W. B. Pierce	So. Ashburnham
United States Spring Bed Co.	Springfield
Heywood Bros. & Wakefield	Wakefield
E. J. Crandall	W. Hawley
Mather & Pierce Co.	Westminster
Kenney Bros. & Watkins	Weston
C. Dodge Furniture Co.	Winchester
Carter & Campbell	Winchendon
Vocation Organ Co.	Worcester

GARDEN AND FARM IMPLEMENTS.

Belcher & Taylor Agr. Tool Co.	Chicopee Falls
Samuel H. Houghton	Harvard
L. S. Crafte	No. Hatfield

GARDEN AND FARM IMPLEMENTS—Con.

H. J. Carnes & Co.	Ludlow
Ames Plow Co.	Worcester
Richardson Mfg. Co.	Worcester
Zoar Mills Co.	Zoar

HANDLES.

H. G. Reed	Conway
The Mossman Wood Turning Co.	Fitchburg
Bolles Bros.	Mattapoisett
J. H. Russell	Melrose
S. A. Healy & Son	No. Chesterfield
Paul Wheeler	Rutland
Amos E. Maynard	Savoy
George A. Thayer	Spruce Corner
F. T. Crosby	Williamsburg
C. A. Brooke	Winchendon

HORSE VEHICLES.

S. R. Bailey & Co.	Amesbury
Wm. O. Loveland	Ashby
E. A. Gillett & Sons	Boston
Henderson Bros.	Cambridge
W. L. Payne	Charlemonst
Archibald Wheel Co.	Lawrence
E. Teel & Co.	Medford
George L. Brownell estate	New Bedford
William E. Mann	Norfolk
Pike & Whipple Co.	Peabody
G. N. Sampson	Plymouth
A. M. Eames & Co.	So. Framingham
Smith & Hubbell	Springfield
Brownell & Burt	Taunton
John J. Grothe	Woburn
Henry Jerome	Worcester

LASTS AND FILERS.

F. W. Stuart & Co.	Beverly
Boston Last Co.	Boston
Brockton Last Co.	Brockton
Mawhinney Last Co.	Brockton
Woodward & Wright	Brockton
Goodwin Bros.	Lynn
Thomes W. Gardiner	Lynn
George P. Cox Last Co.	Malden
Middlesex Last Co.	Malden
Marlborough Last Co.	Marlborough
George E. Belcher Last Co.	Stoughton
Golbert Last Co.	Worcester
S. Porter & Co.	Worcester

MISCELLANEOUS.

Wm. O. Loveland	Ashby
The Diamond Match Co.	Athol
The Atlantic Works	Boston
Boston & Lockport Block Co.	Boston
Oliver L. Briggs & Sons	Boston
Josiah Cunningham & Sons	Boston
New England Trunk Co.	Boston
J. Rush Green	Boston

MISCELLANEOUS—Con.

Sanitas Mfg. Co.	Boston
Hayward Screen Mfg. Co.	Brockton
F. L. Woodbridge	Brockton
National Casket Co.	Cambridge
Standard Turning Works	Cambridgeport
Horatio Bisbee	Chesterfield
C. S. Damon	Chesterfield
A. G. Spalding & Bros.	Chicopee
J. Stevens Arms & Tool Co.	Chicopee Falls
W. A. Fuller	Clinton
E. F. Hodgson	Dover
F. J. Smith & Co.	Fitchburg
Webber Lumber Co.	Fitchburg
Florence Furniture Co.	Florence
George C. Tarr	Gloucester
Samuel H. Houghton	Harvard
H. F. Purce	Huntington
S. F. Canney	Ipswich
William K. Aldrich Co.	Lowell
Willis H. Bean	Lowell
H. Carver & Co.	Ludlow
M. E. Killam	Lynn
J. H. Russell	Melrose
Norwood Engineering Co.	Northampton
John D. Ondréss	Otis
G. N. Sampson	Plymouth
J. N. Crowe & Co.	Salem
The Horton & Hubbard Mfg. Co.	Somerville
C. W. H. Moulton Co.	Somerville
Charles Hyde	Southbridge
S. N. Farrar & Son	So. Royalston
E. A. Jordan	W. Cummington
E. J. Crandall	W. Hawley
F. T. Crosby	Williamsburg
J. W. Loring & Son	Worcester
William C. Sampson	Worthingto
C. W. Bryant	Zoar

MUSICAL INSTRUMENTS.

The Theo. Schwamb Co.	Arlington
A. M. McPhail Piano Co.	Boston
Briggs Piano Co.	Boston
Everett Piano Co.	Boston
Hallett & Davis Piano Co.	Boston
Mason & Hamlin Co.	Boston
Merrill Piano Mfg. Co.	Boston
Vose & Sons Piano Co.	Boston
Ivers & Pond Piano Co.	Cambridge
Seaverns Piano Action Co.	Cambridge
Standard Action Co.	Cambridge
Ernest M. Skinner Co.	Dorchester
Edmund Cole Piano Co.	Fall River
Trowbridge Piano Co.	Franklin
J. H. Locky Piano Case Co.	Leominster
F. G. Smith	Leominster
Wellington Piano Case Co.	Leominster
A. Merriam Co.	So. Acton
J. W. Stine & Son Organ Co.	Springfield
E. W. Lane	Waltham
Beckwith Bros. & Co.	Westfield
Emmons Howard	Westfield
Hook & Hastings	Weston

MUSICAL INSTRUMENTS — Con.

Simplex Piano Player Co.	Worcester
A. Stevens & Sons	Worthington

RAILWAY AND STREET CARS.

The Laconia Car Co. Works	Laconia
Keith Car & Mfg. Co.	Sagamore
Osgood Bradley & Sons	Worcester

REFRIGERATORS.

D. Eddy & Sons Co.	Boston
A. D. Hall & Son	Boston
A. E. James Co.	Boston
O. M. Whitman & Co.	Boston
F. A. Atherton	Worcester

SHUTTLES, SPOOLS, BOBBINS, ETC.

Frary Mfg. Co.	Charlemont
Chester Mfg. Co.	Chester
Dana S. Courtney	Chicopee
W. L. Parker	Lowell
Union Shuttle Co.	Lawrence
Weld Bobbin & Spool Co.	Lawrence
The Hall Bobbin Co.	No. Adams

SHUTTLES, SPOOLS, BOBBINS, ETC. — Con.

M. H. Parks Co.	Winchendon
Winchendon Spool & Bobbin Co.	Winchendon

TOYS.

Frary Mfg. Co.	Charlemont
Noble & Cooley branch of Hardware and Woodenware Mfg. Co.	Granville
American Toy Mfg. Co.	Salem
Mason & Parker	Winchendon

WHIPS.

Horatio Bisbee	Chesterfield
A. F. Purce	Huntington
H. E. Stanton	Huntington
W. J. McCarthy	Westfield
New England Whip Co.	Westfield
W. C. Sampson	Worthington
United States Whip Co. (American Whip Co. branch)	Westfield
H. M. VanDeusen Whip Co.	Westfield

USES BY SPECIES.

The manufacturers in Massachusetts report the use of 54 different woods. The principal purposes for which each is employed are shown in the list which follows: —

AFRICAN WALNUT.

Furniture
Interior finish
Ash.
Automobile bodies
Baby carriages
Balusters
Banjoes
Baskets
Boat frames
Brush backs
Cabinet work
Car finish
Car frames
Carriage bodies
Castors
Dowels
Drums
Furniture
Go-carts
Gymnasium goods
Harps
Hobby horses
Measure rims
Molding
Newel posts
Piano cases

ASH — Con.

Picker sticks
Pipe organs
Pung frames
Rakes
Refrigerators
Sieves
Shipbuilding
Shovel handles
Showcase frames
Sleds
Sleighs
Snow plows
Snow shovels
Stair rails
Tambourines
Tennis rackets
Wagon gears
Wheel rims
Woolen mill cabinets

APPLEWOOD.

Boat knees
Box handles
Engraving blocks
Wooden type
Yacht ribs

BALSAM FIR.

Boxes
Clothboards
Crates
Frames
Shoe cases

BAMBOO.

Reaper whip handles

BASSWOOD.

Baby carriages.
Barrel heading
Boat templets
Bobbins
Boxes for confectionery
Car roofing
Crates
Cupboards
Drug store fixtures
Drums
Fillers
Hollow lasts
Kitchen tables
Medicine cabinets
Molding
Penholders
Picture frames

BASSWOOD — Con.

Piano skeletons
Pipe organs
Pyrography wood
Reed ribs (in cloth mills)
Shirt-waist boxes
Shoe frames
Showcase tables
Skewers
Spirit levels
Spools
Toys
Trunks

BEECH.

Balls
Baskets
Bobbins
Brush backs
Bucket handles
Children's cradles
Cores for veneering
Crochet hooks
Furniture
Interior finish
Lasts
Novelties
Piano posts
Plane stocks
Rolling hoops
Round boxes
Skewers
Slack cooperage
Soap sticks
Spools
Swings
Tool handles
Toys
Turned wood
Whip stocks
Valve handles

BIRCH (SWEET).

Banjos
Billiard tables and fixtures
Boring machine frames
Brush backs
Cabinets
Carriage bodies
Children's cribs
Counters
Druggists' fixtures
Drums
Flooring
Furniture
Gymnasium goods
Harps
Interior finish
Keys for musical instruments
Molding
Panels
Piano cases and hammers
Picture frames

BIRCH (SWEET) — Con.

Platforms for scales
Posts
Refrigerators
Showcases
Soda fountains
Spindles
Stair rails
Stools
Tambourines
Tennis rackets
Trim for passenger cars
Turned toys

BLACK GUM.

Agricultural implements
Furniture
Gun stocks
Interior trim
Panel work
Piano trusses
Pipe organs
Porch posts

BLACK WALNUT.

Balusters
Brushes
Carpenters' tools
Furniture
Interior finish
Mantels
Molding
Organs
Package handles
Pianos
Picture frames
Pipe organs
Railing
Stair work
Tennis rackets

Boxwood.

Plumbers' wood
Plumbers' tools
Billiard material

BUTTERNUT.

Boats
Piano cases
Pipe organs

CHERRY.

Automobile bodies
Boats
Cabinets
Car finish
Carriage panels
Furniture
House finish
Molding

CHERRY — Con.

Organ panels
Penholders
Pianos
Picture frames
Sample-case boxes
Spirit levels
Stair work
Tool handles
Yacht trim

CHESTNUT.

Agricultural implements
Billiard tables and fixtures
Boxes
Cars
Children's cradles
Crates
Furniture
Gymnasium goods
House finish
Molding
Mission furniture
Piano cases
Picture frames
Pipe organs
Showcase doors
Slack cooperage
Stable floors
Stair work
Tool chests
Toys

CIRCASSIAN WALNUT.

Cabinets
Furniture
Interior finish
Musical instruments

COCOA.

Tree sticks (used in shoe factories)

COTTONWOOD.

Boxes
Showcases
Musical instruments

CYPRESS.

Balusters
Boats
Cabinets
Cranberry separators
Doors
Furniture
Interior finish
Molding
Picture frames
Porch posts
Screen frames
Showcases

CYPRESS — Con.

Stair work
Weatherboarding
Weather strips

DOGWOOD.

Shuttles
Golf goods

DOUGLAS FIR.

Flooring
Gutters
Interior finish
Masts
Molding
Organs
Porch columns
Portable houses
Spars

EBONY.

Brush backs
Gavels
Handles
Organ keys
Pedals
Society goods

ELM.

Agricultural implements
Baskets
Boxes
Crates
Hoops of many kinds
Hubs
Parts of furniture
Parts of pianos
Refrigerators
Showcase tables
Slack cooperage
Soda fountains
Trunk slats
Wheel rims

ENGLISH OAK.

Interior finish
Tables

FIR.

Boxes
Crates
Packing cases
Slack cooperage

HACKMATACK.

Boat building

HAZELWOOD.

Piano legs

HEMLOCK.

Boxes
Cloth boards
Crates
Mill cabinets
Organs
Siding
Stair work

HICKORY.

Automobile gears
Baskets
Carriage poles
Golf clubs
Gymnasium goods
Handles
Heel cutter's mallets
Rims for measures
Rolls
Screens
Shafts
Trunk slats
Wagons
Wheels

HOLLY.

Brush backs

ITALIAN WALNUT.

Furniture
Interior finish

LIGNUM VITÆ.

Boat finish
Bowling balls
Castor wheels

LOBLOLLY PINE.

Boats

LONGLEAF PINE.

Boats
Flooring
Freight cars
Inside finish
Molding
Parts of machines
Passenger cars
Pipe organs

MAHOGANY.

Automobile bodies
Actions for piano players
Canoe trim
Counter tops
Drugstore fixtures
Furniture
House finish
Molding
Newel posts
Organs
Passenger car finish

MAHOGANY — Con.

Piano cases
Picture frames
Showcases
Stair work
Tennis rackets
Yacht finish

MAPLE.

Agricultural implements
Athletic goods
Balusters
Banjos
Baskets
Bobbins
Boxing machine frames
Boxes
Brush blocks
Brush handles
Butter printers
Candlepins
Car finish
Carriage bodies
Children's cradles
Church organs
Clamp jaws
Cottage organs
Crates
Cutter frames
Die blocks
Drums
Flooring
Furniture
Games
Go-carts
Gymnasium goods
Handles
Harps
Interior finish
Lasts
Meat blocks
Pianos
Piano player actions
Railing
Rolls
Skewers
Slack cooperage
Soap sticks
Spools
Swings
Tambourines
Tennis rackets
Ten pins
Toys
Turnery
Whip butts
Wire mattress frames

NORTH CAROLINA PINE.

Blinds
Boxes
Cloth boards
Crates

NORTH CAROLINA PINE — CON.

Doors
Flooring
Freight car siding
Gymnasium goods
Interior finish
Pipe organs
Refrigerators
Sash
Screens
Stair work
Snow plows
Wagons

NORWAY PINE.

Freight car siding
Walking planks

PERSIMMON.

Billiard cues
Golf stick heads
Mallets
Shuttles

PITCH PINE.

Boxes
Crates
Heading for barrels
Staves

PRIMA VERA.

Musical instruments

QUASSIA.

Quassia chips
Quassia cups

RATTAN.

Furniture

RED CEDAR.

Boats
Furniture
Interior finish
Yacht trim

RED GUM.

Piano skeletons

RED OAK.

Baskets
Boat finish
Furniture
Interior finish
Refrigerators
Rolling hoops
Snow plows
Stair work
Wagons

REDWOOD.

Carriage bodies
Cupboards

REDWOOD — CON.

Flooring
Furniture
Gutters
Molding
Pianos
Wagon tops

ROSEWOOD.

Brush backs
Gavels
Piano cases
Society goods
Tool handles

SPANISH CEDAR.

Boats
Furniture
House finish
Yacht trim

SPRUCE.

Agricultural machines
Barrel bungs
Blinds
Bobbins
Boxes
Butter cases
Car roofing
Cloth boards
Crates
Doors
Furniture
Hobby horses
Interior finish
Mill cabinet work
Organs
Piano skeletons
Plugs
Refrigerators
Sash
Screens
Shoe racks
Slack cooperage
Sounding boards
Spars and yards
Spruce oil
Stair work
Stakes

SUGAR PINE.

Blinds
Interior finish
Pipes for church organs

SYCAMORE.

Boats
Furniture
Interior finish
Pipe organs

TEAK.

Boats
Bowling balls

WESTERN CEDAR.

Yachts

WHITE CEDAR.

Boats
Panels
Piazza columns
Tanks
Tennis rackets
Tubs and pails
Wedges

WHITE BIRCH.

Baby carriages
Balls
Baskets
Bobbins
Brush backs
Children's chairs
Coffin handles
Doorknobs
Dowels
Novelties
Package handles
Penholders
Screens
Skewers
Slack cooperage
Spindles
Spools
Tackle blocks
Toys
Turnery
Wagons
Whip butts
Wire mattress frames

WHITE OAK.

Agricultural machines
Baskets
Billiard tables
Boats
Bungs
Cabinets
Church organs
Church pews
Cottage organs
Die blocks
Doors
Flooring
Freight cars
Furniture
Gymnasium goods
Handles
Hobby horses
Interior finish
Measure rims
Molding
Panels
Parquetry
Passenger car finish
Pianos
Picture frames

WHITE OAK — Con.

Plow beams and handles
Plugs
Pulpits
Refrigerators
Screens
Showcases
Showcase tables
Snow shovels
Soda fountains
Stair work
Tight cooperage
Toys
Trunk slats
Turnery
Wagon wheels and gears

WHITE PINE.

Agricultural machines
Automobile bodies
Baby carriages
Barrel heads and bungs
Blinds
Bottoms for measures
Bottoms for showcases
Brackets
Boxes
Carriage bodies
Children's wheelbarrows
Chocolate boxes
Church organs
Cloth boards
Crates
Cutting boards
Doors
Egg carriers
Freight cars
Furniture
Golf goods
Hobby horses
Hothouse sash
Matches
Mill cabinets
Pails

WHITE PINE — Con.

Patterns
Penholders
Piano cases
Piano keys and key beds
Refrigerators
Sash
Screens
Showcases
Showcase tables
Shoe racks
Snow plows
Soda fountains
Tanks
Tobacco cases
Toys
Trunks
Wagon bodies
Warehouse car bottoms
Weather strips
Window frames
Woodenware
Yacht decks

WILLOW.

Baskets
Furniture

YELLOW BIRCH.

Baskets
Bobbins
Brushes
Chairs
Go-carts
Handles
Interior finish
Skewers
Slack cooperage
Soap sticks
Spools
Stretchers
Swings
Toys
Turnery

YELLOW OAK.

Furniture
Snow plows
Wagons

YELLOW POPLAR.

Actions in piano players
Agricultural implements
Automobile bodies
Balusters
Billiard tables
Boats
Bobbins
Boxes
Brackets
Brushes
Cabinets
Car finish, roofing and siding
Carriage panels
Chocolate boxes
Crates
Church organs
Doors
Drums
Fillers
Frames
Furniture
Gymnasium goods
Hobby horses
Interior finish
Molding
Newel posts
Panels
Penholders
Pianos
Railing
Refrigerators
Screens
Shelving
Showcase doors
Spools
Stair work
Steamboat finish
Weather strips

Walter Mulford

The Chestnut Bark Disease



A Grave Danger which Threatens
Our Forest Trees, with
Its Remedy

STATE FORESTER'S OFFICE
BOSTON, MASS.

F. W. RANE, STATE FORESTER



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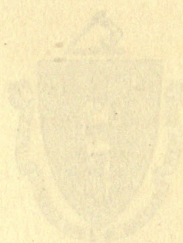
The Chestnut Bark Disease



A Grave Danger which Threatens
Our Forest Trees, and
its Remedy

APPROVED BY
THE STATE BOARD OF PUBLICATION.

STATE FORESTER'S OFFICE
BOSTON, MASS.
E. W. HARRIS, STATE FORESTER



PRINTED BY THE STATE FORESTER
AT THE STATE PRINTING OFFICE
BOSTON, MASS.

Walter Mulford

THE CHESTNUT BARK DISEASE.

THE DISEASE AND ITS METHOD OF ATTACK.

The State Forester wishes to call the attention of the citizens of the Commonwealth to a serious disease of the common chestnut (*Castanea dentata*), — a disease which has been working for some time in the States of New York, New Jersey, Connecticut and Pennsylvania, and which has been found to be slowly gaining a foothold in Massachusetts. This disease is caused by a fungus known botanically as *Diaporthe parasitica* (also as *Valsonectria parasitica*), and grows in and derives nourishment from the tissues of the inner bark of the chestnut tree. The fungus is conveyed from one place to another by means of “spores” or fruiting bodies, which are analogous to seeds in the higher orders of plants. These spores, being small and very light, are easily carried long distances by the wind, and when blown against a chestnut tree find lodgment in any wounds, of which even the healthiest tree often has a great many, that may be in the bark. It makes no difference with the disease whether the spores find a refuge in the tissues of the thick bark of the trunk or the thinner bark of the small twigs, — the fungus develops equally well. It is true that in localities where the disease is rare the spread is slow, but the fact that it can increase to an alarming rate has been proved in our sister States, where it is no exaggeration to say that in certain sections the chestnut is becoming extinct.

GROWTH.

The spores having gained an entrance, the fungus begins to spread by sending out many small fibers, much in the same way that a plant sends out roots. These fibers, pushing about and through the growing cells of the tree to obtain nourishment, form a close network which soon saps the life of the section where they are.

Now, the serious part of this process of growth, looked at from the tree standpoint, lies in the fact that the fungus shows a marked tendency to grow around the infected branch or stem, thus girdling it, and killing all growth above that point. When this happens to the trunk of a tree it is easily seen that it becomes a serious matter.

Furthermore, the trunk of a tree may be infected by spores coming from diseased parts of its own branches, thus multiplying the disease within itself so to speak.

APPEARANCE OF DISEASED PARTS.

The following features are characteristic of the external appearance of the diseased tree. The outer bark over the diseased part is of a slightly reddish tinge, more so than the rest of the bark, and as the disease progresses this reddish area becomes covered with yellowish, brownish, or orange-colored pustules. Further, in damp weather or damp situations the spores are often extruded in the form of greenish-yellow "strings." The bark splits open up and down the length of the infected spot and often shows a swelled appearance. The cracks are filled with twisted and criss-crossed fibers of a slightly yellowish color. Among the smaller branches the cracks are of course less visible, but they still occur.

It should be here stated that these same characteristics may be the result of the work of other species of fungi than the one in question, and therefore, in order to be sure, specimens should be sent to a botanist for a microscopic examination. Such identification will be gladly made by the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., or by the Massachusetts Agricultural College, Amherst, Mass.

TIME FOR MAKING OBSERVATIONS.

The best time for seeing the evidences of the work of this fungus is the season now approaching, viz., in the spring, when the leaves begin to appear. The reason for this is not that the disease does the greatest amount of damage at this time, but because trees that have been injured the previous season by having much of their live tissue destroyed, instead of putting forth



Two trees killed by the disease. Note the dilapidated or shreddy appearance of the bark and the few persistent dead leaves; also, portion of upper part of left-hand tree, where bark is falling off. (All photographs taken at Wilbraham, Mass., Feb. 23, 1911.)



Infested trunk, showing how bark splits open.
(This is a nearer view of section marked "y"
in photograph to the left.)

Infested stem. The fungus
tends to girdle the dis-
eased portion rather than
to extend up and down.
"x" and "y" are dis-
eased sections.

healthy new leaves can produce only sickly and stunted foliage, the extent of the blighted area depending on whether the main stem or only a branch was attacked.

METHODS OF CONTROL.

It should be understood that there is no known method of curing the disease, or of saving woodland once it has become thoroughly infested. The experience of other States has proved this. Nor is it possible to save single trees, if badly diseased, except at great expense, and even then the chance for failure is great, owing to the impossibility of locating all the infected spots.

VIGOROUS MEASURES NEEDED IN EARLY STAGES.

To check its spread at the beginning of its entrance into a locality is, therefore, the only hope, and this hope is considered a strong one by those who have studied the disease most.

Dr. Haven Metcalf, who is the pathologist in charge of investigating this blight for the government Bureau of Plant Industry, and who has spent a great deal of time in this work, states that "in all cases we know of where the disease has been carefully eradicated, in localities where it has just appeared, the work has been very successful; so that we feel warranted in advising a very considerable outlay of energy to eradicate the disease at the outset."

METHODS OF ERADICATING.

Inspection of Nursery Stock.

There are several ways of going about the eradication of the blight. All chestnut nursery stock should be carefully inspected for signs of the disease, as such stock has heretofore apparently been one of the chief agencies of spreading the fungus. This precaution should be taken by nurserymen and purchasers alike.

Prompt Destruction of Diseased Trees.

A careful inspection of trees for evidences of the disease should be made by all owners of chestnut woodland during the months of May and June, and any tree found infected should at

once be cut down, the wood put into marketable form, and all brush, and if possible all patches of diseased bark, burned at the first opportunity. If this is not done, the down tree merely becomes a center of infection for the rest of the woods, as it is known that the fungus may live on dead bark for at least six months after cutting.

In answer to the question as to whether sprouts from the stumps of infected trees that have been cut will also themselves be infected, it should be said that for the first year at least they will not be, but after that they should be carefully examined for signs of the disease.

TREATMENT OTHER THAN CUTTING.

Spraying.

Experiments have shown it to be a matter of doubt as to whether the spraying of infected trees is of any avail against this fungus. It is possible, however, that in the case of valuable shade trees very frequent sprayings might have a tendency toward preventing infection.

Broken limbs, wounds, cracks and crotches of branches are fruitful sources of attack, and the fungus should be looked for at these points.

Local Cutting of Infected Spots.

The other method of individual treatment that has proved successful, though only in the case of valuable trees, where the expense was warranted, is the one of cutting and removing all patches of diseased bark and carefully protecting the exposed surface with a coat of tar or paint. This treatment must be thorough, and even then it will do no good if the disease has progressed too far. Infected branches should be removed altogether, at a good distance below the point of infection, and any bark cutting should be done at least an inch beyond and outside of the discolored area, which shows the location of the fungus.

A tree that has been already girdled should be cut down at once, and trees under treatment should be inspected frequently, say about June 1, July 15 and September 1, or oftener in wet weather.

CO-OPERATION NECESSARY.

It is believed that by carefully following the foregoing instructions the disease can be kept under control in Massachusetts, with the constant hope that some natural enemy will appear to assist in the work. No controlling enemy, however, is known at present. All persons are therefore urged to do their utmost, either by reporting cases to this office or by actively using some of the above measures of control, to aid in checking this enemy of one of our best timber trees.

BIBLIOGRAPHY.

Reference is made to the publications of the United States Department of Agriculture on this subject, especially Bulletin 141, Part V., of the Bureau of Plant Industry, from which several extracts, including quoted passages in this pamphlet, have been taken (those who are interested are advised to obtain a copy of this bulletin); also to a report of the Main Line Citizens' Association of Haverford, Pa.

CONCLUSION.

Lest the serious results of this disease be underestimated, the following instances of its work in other localities are cited:—

“A survey of the Forest Park, Brooklyn, showed ‘that 16,695 chestnut trees were killed in the 350 acres of woodland in this park alone. Of this number, about 9,000 were between 8 and 12 inches in diameter, and the remaining 7,000 or more were of larger size.’”

“In a recent publication Dr. W. A. Murrill estimates the financial loss from this disease ‘in and about New York City’ at ‘between five and ten million dollars.’”

With this loss in a city it can readily be seen what an enormous loss would occur should the disease become prevalent in the woodlands.

It becomes a question, therefore, as to which is the better economy, — to do nothing, and lose our chestnut trees, or to do our utmost at this early stage, with a fair chance of saving them.

CHESTNUT

ITS MARKET IN MASSACHUSETTS.

A COMPILATION PREPARED FOR THE
MASSACHUSETTS STATE FORESTER

In co-operation with the Office of Investigations in Forest Pathology, Bureau
of Plant Industry, United States Department
of Agriculture

By

JOHN MURDOCH Jr., Agent
Investigations in Forest Pathology, Bureau of Plant Industry
United States Department of Agriculture

F. W. RANE, State Forester
B. T. GALLOWAY, Chief of Bureau



BOSTON
WRIGHT & POTTER PRINTING CO., STATE PRINTERS
18 POST OFFICE SQUARE
1912

CHESTNUT

ITS MARKET IN MASSACHUSETTS

MASSACHUSETTS STATE FORESTER

IN RESPONSE TO THE ORDER OF PUBLICATION OF THE
MASSACHUSETTS STATE FORESTER
OF THE FOREST SERVICE OF THE UNITED STATES
DEPARTMENT OF AGRICULTURE

JOHN MURPHY, JR.

APPROVED BY
THE STATE BOARD OF PUBLICATION.

E. W. KANE, JR.
E. E. GILBERT, JR.



MASSACHUSETTS STATE FORESTER
OFFICE OF THE STATE FORESTER
100 STATE STREET
BOSTON, MASS.

INTRODUCTION.

The presence of the chestnut bark disease in Massachusetts has led many owners of chestnut timber to wish to dispose of their holdings before they are destroyed. This office is constantly in receipt of requests for information as to the market for such timber. It has, therefore, seemed advisable to compile all the data available on the subject. Bulletin 154 of the Connecticut Agricultural Experiment Station and Bulletin 96 of the Forest Service, United States Department of Agriculture, contain much valuable information. This has been brought together and adapted to Massachusetts conditions, with additional data now collected for the first time. The work has been done by John Murdoch Jr., acting as Agent in the Office of Investigations in Forest Pathology, Bureau of Plant Industry, under furlough from this office. Acknowledgment is hereby made to the Forest Service and to the State Forester of Connecticut for the data which they have permitted us to use from their bulletins. Thanks are also due for information concerning poles and ties to the following:—

Boston & Albany Railroad.

Central Vermont Railway Company.

Boston & Maine Railroad Company.

New York, New Haven & Hartford Railroad Company.

Bay State Street Railway Company.

Berkshire Street Railway Company.

Boston Elevated Railway Company.

Boston & Worcester Street Railway Company.

Massachusetts Northern Railways.

Middlesex & Boston Street Railway Company.

Springfield Street Railway Company.

Worcester Consolidated Street Railway Company.

New England Telephone and Telegraph Company.

And a number of operators whose names it is not considered advisable to print.

By a co-operative agreement with the Bureau of Plant Industry, this office is now prepared to furnish advice on the handling of chestnut wood lots in which the disease is present or threatening, without making a charge for the expenses of the examiner, as has previously been necessary. Blank applications for such examinations may be obtained from this office.

F. W. RANE,
State Forester.

CHESTNUT: ITS MARKET IN MASSACHUSETTS.

DESCRIPTION.

The chestnut, *Castanea dentata*, in this State seldom grows over 90 feet high, with a diameter of 1 to 2 feet. In the open it sometimes reaches a diameter of 4 to 6 feet, but it is then shorter and has a brushy crown. The leaves are oblong-lanceolate in shape, 6 to 8 inches long, with acute apex, wedge-shaped base and dentate margin. The flowers, which appear about the 4th of July, are creamy white, in slender catkins 6 to 8 inches long. The fruit is a bur containing from 1 to 3 nuts.

The typical form in which chestnut occurs in Massachusetts is an even-aged sprout stand. This results from the common practice of clean cutting. Following such an operation, practically every chestnut stump sends up a number of vigorous sprouts, which soon close together and form a complete cover. The weaker sprouts are soon shaded out, as are any seedlings which may have started, and the resulting stand is of nearly even height as well as age. Chestnut rarely reproduces by seed in the forest, since it is unable to endure shade.

Chestnut frequently occurs in nearly pure stands, and frequently also is mixed with different species of oak. White pine sometimes occurs in mixture, its ability to endure a certain amount of shade and its rapid growth when once started enabling it to hold its own with the more rapidly starting chestnut.

The State Forester of Connecticut has determined that the average growth of sprout chestnut is as follows:—

AGE (YEARS).	Height (Feet).	Diameter (Inches).
20, ...	36	3
40, ...	62	9
60, ...	70	16
80, ...	74	22
100, ...	77	28

MARKET.

Lumber.

Chestnut lumber has many uses. Perhaps the most important for the native article is in bridge construction. It is especially adapted to this, owing to its durability when exposed to moisture. It is also used to a considerable extent in the construction of buildings, as framing, rough siding and sometimes as coarse shingles. Native chestnut is also used in the manufacture of agricultural implements, boxes and crates, furniture, house finish and stair work, slack cooperage, and toys, such as tool chests and wagons. In 1908, the amounts used in Massachusetts and the prices paid were as follows: —

PRODUCT.	Per Cent. of Total used grown in State.	Quantity from Massachusetts (Feet B. M.).	Average Price at Factory.
Boxes and crates, ...	33	782,000	\$16 36
Furniture, ...	46	2,284,500	24 36
Musical instruments, ...	8	300,000	23 33
Interior finish and stair work, ...	92	310,000	20 13
Cooperage, ...	100	110,000	15 00
Agricultural implements, ...	100	50,000	15 00
Toys, ...	100	158,000	13 14

It will be seen that there is a very considerable market for chestnut in the furniture industry. This requires lumber free of wormholes, and otherwise nearly clear.

It is difficult to form any estimate of the amount of lumber employed in bridge and building construction, since these uses are very largely local.

The current prices range as follows: —

Bridge plank, \$20, \$24, \$25, \$28, \$30, \$31.

Bridge timbers, \$21, \$25.

Framing timbers, \$25, \$32.

Chair lumber, \$30, \$35 f. o. b. factory (surface measure, 1½ inches).

Tie sidings, \$15 (used for toys, etc.).

Boards: —

Mill run, \$20 (wholesale price), \$28 (retail price).

Clear, \$40 (retail price).

Covering boards, \$22 (retail price).

TIES.

The specifications for ties vary according to the company. The Boston & Albany Railroad has three classes of 8-foot ties. "First-class," if sawed on all four sides, must have 8 inches face and 7 inches thickness; if flattened on only two sides, they must have at least 7 inches face. "Second-class" ties are 7 by 7 inches squared, or with 6 to 7 inches face if flattened on two sides. "Third-class" ties are 6 inches thick, with face of 8 inches if squared, or 6 inches and up if flattened.

The New York, New Haven & Hartford and the Boston & Maine Railroads publish identical specifications. "No. 1" ties, if sawed square, are to have 7 inches thickness and 9 inches face; if flattened, 7 to 12 inches face. "No. 2" ties are 6 inches thick, with 8-inch face if squared, or 6 to 12-inch face if flattened. "No. 3" are the same as "No. 2," with 1 inch less face. The right is reserved to "limit the proportion of No. 2 and No. 3 ties."

The Central Vermont Railway takes two classes of ties, both 8 feet long and 6 inches thick. "No. 1" are 6 inches or over on the face if flattened, and 8 to 9 inches if squared. "No. 2" have 5 inches face if flattened, and 6 to 8 inches if squared.

Many of the electric railways use 8-foot ties 6 inches thick, of which the first class have a face of 6 inches or over and the second 5 inches or over if flattened, or corresponding widths if sawed square. Some of the roads make a flat price for all ties, accepting not more than 10 per cent of the total in second-class.

The Boston Elevated and the Middlesex & Boston use only 7-foot ties, in one class, which is 6 inches thick, by 8 inches face if squared, or 6 to 9 inches if flattened.

All the specifications call for ties cut from sound, living timber, and freed from bark. Some of the companies demand winter-cut ties.

The published prices are as follows: —

DIMENSIONS (SQUARED).	Prices (Cents).
7 by 9 inches by 8 feet, ...	70
7 by 8 inches by 8 feet, ...	65
7 by 7 inches by 8 feet, ...	60
6 by 8 inches by 8 feet, ...	46, 50, 55, 60
6 by 7 inches by 8 feet, ...	30, 35, 40
6 by 8 inches by 7 feet, ...	45 (52½ on track), 55-60 f. o. b. Boston.

Switch timbers are sawed square, 7 by 9 inches, and in lengths as ordered. The price is \$18 to \$20 per M feet b. m.

Poles.

The general specifications for poles are: cut from living timber, reasonably straight, free from rot, shakes or large knots, limbs trimmed close and bark peeled. They must conform to the following minimum dimensions:—

LENGTH (FEET).	Diameter at Top (Inches).	Diameter 5 Feet from Butt (Inches).
30, ...	7 (8) (9)	11 ¹ (12) (14)
35, ...	7 (8) (9)	12 (13) (15)
40, ...	7 (8)	14 (14)
45, ...	7	15
50, ...	7	16
55, ...	7	17
60, ...	7	18
65, ...	7	18½
70, ...	7	18½

¹ One company specifies a butt diameter of 12 inches with 7-inch top.

The New England Telephone and Telegraph Company, the largest user of poles in the State, specifies dimensions as follows:—

[Circumference in inches 6 feet from top or butt.]

LENGTH (FEET).	CLASS A.		CLASS B.		CLASS C.		CLASS D.		CLASS E.	
	Top.	Butt.	Top.	Butt.	Top.	Butt.	Top.	Butt.	Top.	Butt.
25, ...	—	—	—	—	20	30	20	27	15½	26
30, ...	24	40	22	36	20	33	20	31	15½	29
35, ...	24	43	22	40	20	36	20	35	20	34
40, ...	24	45	22	43	20	40	20	39	20	38
45, ...	24	48	22	47	20	43	20	43	20	42
50, ...	24	51	22	50	20	46	20	46	20	46
55, ...	22	54	22	53	20	49	—	—	—	—
60, ...	22	57	22	56	—	—	—	—	—	—

The prices for poles vary as follows:—

LENGTH (FEET).	Prices.
25, ...	\$1, \$1.83
30, ...	\$2.50, \$3, \$3.50, \$4, \$4.50 ¹
35, ...	\$3.38, \$4, \$4.50, \$5, \$5.50, \$6 ¹
40, ...	\$5.50, \$5.75, \$6, \$7, ¹ \$8 ¹
45, ...	\$6, \$6.60, \$8
50, ...	\$9, \$10
55, ...	\$15, \$18
60, ...	\$18, \$22
65, ...	\$30

¹ These prices were given for poles delivered at the hole.

The higher prices for each length are generally for poles of the larger diameters shown above. It should be understood that there is no certainty of obtaining the price given for any pole, but that these are simply prices which have recently been paid by the various companies for poles of the given dimensions.

Cordwood.

Cordwood in general has a smaller market value, volume for volume, than other of the principal forest products. Chestnut in particular has a low value as cordwood, the price running from \$3 to \$4.50 per cord. The market is limited. In Berkshire County the lime kilns use much chestnut wood, and it is occasionally burned for charcoal. In the Connecticut valley a good deal is also used in the brick yards. Elsewhere the demand is largely supplied by other species of higher fuel value. The low price limits the profitable haul for chestnut wood to a comparatively short distance.

COST OF PRODUCTION.

The most variable item in the cost of production is hauling. This varies with both the length of haul and the rate of wages. It is ordinarily assumed that a work team can average 18 miles a day, half loaded and half light, over average roads. The wages of team and driver ordinarily vary from \$4.50 to \$5.50

per day. In some sections \$6 is the usual rate. Table 1 gives the hauling cost for different wage rates and distances.

TABLE 1. — *Costs of Hauling.*

[Reprinted from Forest Service Bulletin 96.]

Wage rate, ...	\$4.50.	\$5.	\$5.50.
DAILY HAULING CAPACITY FOR 1 TEAM.	Hauling Cost per Load.		
1 load, ...	\$4 50	\$5 00	\$5 50
2 loads, ...	2 25	2 50	2 75
3 loads, ...	1 50	1 67	1 83
4 loads, ...	1 13	1 25	1 38
5 loads, ...	90	1 00	1 10

Table 2 gives the average costs of production, except hauling, of the different products, as determined for Connecticut.

TABLE 2. — *Costs of Production.*

[Compiled from tables in Forest Service Bulletin 96.]

	LUMBER PER M FEET B. M.		Ties per M Feet B. M.	Cordwood per Cord.
	Minimum.	Average.		
Cutting, ...	\$1 25	\$1 50	\$1 50	\$1 00
Skidding, ...	1 50	1 75	1 75	-
Sawing, ...	2 50	3 50	2 00	-
Piling, ...	1 00	1 00	-	-
Peeling, ...	-	-	35	-
Total, ...	\$6 25	\$7 75	\$5 60	\$1 00

Cost of cutting and peeling poles assumed to be 30 cents for poles 25 to 35 feet long; 35 cents for poles over 35 feet long.

The average cost of production of lumber in Massachusetts, as given by various operators, seems to be lower than that in Table 2. The costs given run from \$4.50 to \$7. In the following tables, therefore, the minimum Connecticut cost has been used as the average Massachusetts cost.

Table 3 gives the combined costs of production and hauling per unit of volume, based on the figures in Tables 1 and 2, for different daily capacities and wage rates. Since no estimate of

costs is complete without including interest on the money invested in the operation, 6 per cent. has been added to cover this charge.

TABLE 3.—*Cost of lumbering and hauling Different Products, with Interest Charges at 6 Per Cent.*

[Compiled from tables in Forest Service Bulletin 96.]

DAILY HAUL- ING CAPACITY FOR 1 TEAM.	Team- ing Wage Rate per Day.	Cost per M Feet B. M. Lumber.	Cost per M Feet B. M. Ties.	COST PER POLE.				Cost per Cord.
				25 to 30 Foot (6 per Load).	35 Foot (4 per Load).	40 to 45 Foot (2 per Load).	50 Foot (1 per Load).	
1 M lumber, 1 M ties or 1 cord wood, . . .	\$5 50	\$12 45	\$11 77	\$1 29	\$1 78	\$3 29	\$6 20	\$6 89
	5 00	11 92	11 24	1 20	1 64	3 02	5 67	6 36
	4 50	11 40	10 71	1 11	1 51	2 76	5 14	5 83
2 M lumber, 2 M ties or 3 cords wood, . . .	5 50	9 54	8 85	80	1 05	1 83	3 29	3 00
	5 00	9 28	8 59	76	98	1 70	3 02	2 83
	4 50	9 01	8 32	72	91	1 56	2 76	2 65
3 M lumber, 3 M ties or 5 cords wood, . . .	5 50	8 54	7 88	64	80	1 34	2 31	2 23
	5 00	8 40	7 71	61	76	1 26	2 14	2 12
	4 50	8 22	7 53	58	72	1 17	1 96	2 01

VALUE OF STANDING TIMBER.

The stumpage values for lumber, ties, poles and cordwood here given are derived from the market values and costs of production given above.

The real stumpage value is the difference between the market value and the total operating costs, less a reasonable profit on the combined investment in stumpage and production. The profit has been computed for the purpose of this bulletin at 20 per cent.

Table 4 gives the stumpage value per unit of volume for different hauling capacities, wage rates and market prices, based on the total costs of production given in Table 3. These are the prices which the wood-lot owner should receive for his timber under the given conditions.

TABLE 4. — *Stumpage Value of Different Products after deducting a Lumberman's Profit of 20 Per Cent.*¹
 [Compiled from tables in Forest Service Bulletin 96.]

DAILY CAPACITY.	Team- ing Rate.	LUMBER PER M AT MARKET VALUE.			TIES PER M AT MARKET VALUE.			POLES AT VALUES PER POLE.							CORDWOOD AT VALUE OF —			
		\$18.	\$24.	\$30.	\$11.40. ²	\$16. ³	\$17.50. ⁴	\$1.50.	\$3.	\$4.10.	\$5.30.	\$6.90.	\$9.	\$15.	\$18.	\$3.50.	\$4.	\$4.50.
1 M lumber, 1 M ties or 3 cords wood,	\$5 50	\$2 55	\$7 55	\$12 55	—	\$1 57	\$2 81	—	\$1 21	\$1 64	\$1 13	\$2 46	\$1 30	\$6 30	\$8 80	—	\$0 33	\$0 75
	5 00	3 08	8 08	13 08	—	2 09	3 34	\$0 05	1 30	1 78	1 40	2 73	1 83	6 83	9 33	\$0 09	50	92
	4 50	3 60	8 60	13 60	—	2 62	3 87	14	1 39	1 91	1 66	2 99	2 86	7 36	9 86	27	68	1 10
2 M lumber, 2 M ties or 4 cords wood,	5 50	5 46	10 46	15 46	\$0 65	4 48	5 73	45	1 70	2 37	2 59	3 92	4 21	9 21	11 71	40	81	1 23
	5 00	5 72	10 72	15 72	92	4 74	5 99	49	1 74	2 44	2 72	4 05	4 48	9 48	11 98	53	94	1 36
	4 50	5 99	10 99	15 99	1 18	5 01	6 26	53	1 78	2 51	2 86	4 19	4 74	9 74	12 24	66	1 07	1 49
3 M lumber, 3 M ties or 5 cords wood,	5 50	6 46	11 46	16 46	1 62	5 45	6 70	61	1 86	2 62	3 08	4 41	5 19	10 19	12 69	69	1 10	1 52
	5 00	6 60	11 60	16 60	1 79	5 62	6 87	64	1 89	2 66	3 16	4 49	5 36	10 36	12 86	80	1 21	1 63
	4 50	6 78	11 78	16 78	1 97	5 80	7 05	67	1 92	2 70	3 25	4 58	5 54	10 54	13 04	91	1 32	1 74

¹ The costs used in computing these stumpage values are those given in Table 3.

² 6 by 7 inch ties at 30 cents per tie.

³ 6 by 8 inch ties at 50 cents per tie.

⁴ 7 by 9 inch ties at 70 cents per tie.

Relative Value of Different Products.

Table 5 gives the contents and values of average trees of different sizes in different products, under the teaming conditions and market values given in the note. "Additional wood" is the wood in tops and limbs, which is assumed to be put into cordwood. The first column in the table gives the diameter of the tree outside the bark at $4\frac{1}{2}$ feet from the ground. The second gives the average height of trees of that diameter. The columns headed "value" give the stumpage values of the trees in the given product. Those headed "value and profit" are computed from the combined stumpage and profit, and represent the clear gain, over and above costs, of the owner who does his own logging.

The contents of the different trees are taken from Tables 6, 7, 8 and 9. The figures for ties are those in the Connecticut bulletin, which are lower than the average in the Forest Service bulletin, so the values are correspondingly lower.

TABLE 5. — *Contents and Stumpage Value, with and without Lumberman's Profit, of Trees of Different Sizes in Different Products.*
 [Adapted from tables in Forest Service Bulletin 96 and Connecticut Agricultural Experiment Station Bulletin 154.]

DIAMETER AT BREAST HIGH (INCHES).	Height (Feet).	LUMBER AND ADDITIONAL WOOD.				TIES AND ADDITIONAL CORDWOOD.				POLES AND ADDITIONAL WOOD.				CORDWOOD.					
		Board Feet.	Cords.	AT \$18 PER M.		AT \$24 PER M.		6 by 7.	6 by 8.	Cords.	Value.	Value and Profit.	Length (Feet).	Cords.	Value.	Value and Profit.	Cords.	Value.	Value and Profit.
				Value.	Value and Profit.	Value.	Value and Profit.												
6.	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	\$0 03	\$0 07	
7.	50	-	-	-	-	1	-	-	-	0.03	\$0 04	\$0 11	-	-	-	-	.08	04 09	09 13
8.	55	30	0.07	\$0 21	\$0 34	1	-	.03	04 11	.03	04 11	11 34	-	-	-	-	.11	06 11	15 15
9.	65	40	.07	26 43	46 75	1	1	.03	19 34	.03	19 34	34 75	-	-	-	-	.13	06 15	20 20
10.																	.17	08 20	
11.	65	58	.07	37 59	66 105	1	2	.04	34 59	.04	34 59	59 105	-	-	-	-	.21	10 25	25 25
12.	65	78	.07	48 76	87 139	1	2½	.05	42 70	.05	42 70	70 139	25	0.10	\$0 52	\$0 86	.26	13 30	30 30
13.	65	100	.07	61 95	1 11	1	3	.05	49 83	.05	49 83	83 111	25	.10	52 10	86 35	.30	15 35	35 35
14.	70	122	.08	74 116	1 35	1	3½	.06	57 96	.06	57 96	96 135	30	.11	1 80	2 37	.34	17 40	40 40
15.	70	147	.10	89 140	1 62	1	4	.06	65 107	.06	65 107	107 162	35	.10	2 49	3 24	.41	20 48	48 48
16.	70	172	.10	1 03	1 62	1	4½	.07	72 120	.07	72 120	120 162	40	.08	2 76	3 69	.47	24 55	55 55
17.	70	213	.12	1 28	2 00	1½	5½	.08	87 140	.08	87 140	140 200	40	.10	2 77	3 72	.53	26 62	62 62
18.	70	242	.12	1 44	2 25	1½	6	.09	94 153	.09	94 153	153 225	45	.06	4 08	5 27	.61	30 71	71 71
19.	70	280	.13	1 67	2 59	1½	7	.09	1 09	.09	1 09	1 76	45	.08	4 09	5 29	.70	35 82	82 82
20.	70	308	.14	1 83	2 85	1½	7½	.10	1 17	.10	1 17	1 89	45	.10	4 10	5 31	.77	38 90	90 90
21.	75	340	.18	2 03	3 18	1½	8½	.10	1 32	.10	1 32	2 12	50	.10	4 53	6 10	.86	43 101	101 101
22.	75	375	.21	2 25	3 52	1½	10	.11	1 55	.11	1 55	2 48	55	.06	9 51	12 05	.95	48 111	111 111
23.	75	422	.23	2 53	3 95	1½	11	.12	1 70	.12	1 70	2 72	55	.08	9 52	12 07	1.04	52 122	122 122
24.	75	450	.26	2 70	4 23	1½	12½	.13	1 93	.13	1 93	3 08	55	.10	9 53	12 10	1.14	57 133	133 133
25.	75	488	.29	2 93	4 59	1½	14	.14	2 14	.14	2 14	3 40	55	.12	9 54	12 12	1.25	62 146	146 146
26.	75	530	.31	3 19	4 98	-	16	.15	2 44	.15	2 44	3 87	55	.14	9 55	12 14	1.36	68 159	159 159
27.	75	580	.35	3 49	5 47	-	17½	.16	2 67	.16	2 67	4 23	55	.16	9 56	12 17	1.47	74 172	172 172
28.	80	630	.39	3 60	5 95	-	19	.17	2 90	.17	2 90	4 59	55	.20	9 58	12 21	1.60	80 187	187 187
29.	80	700	.42	4 21	6 60	-	21	.18	3 20	.18	3 20	5 06	55	.22	9 59	12 24	1.72	86 201	201 201
30.	80	800	.46	4 81	7 51	-	24	.19	3 65	.19	3 65	5 77	60	.10	12 03	15 10	1.86	93 218	218 218

Daily hauling capacity of 1 team assumed as 3 cords, 2 M of lumber or ties, or equivalent number of poles. Team wage rate, \$5. Market value of lumber, \$18 and \$24; cordwood, \$4; 6 by 7 inch ties, 30 cents; 6 by 8 inch ties, 50 cents; 25-foot poles, \$1.50; 30-foot, \$3; 35-foot, \$4.10; 40-foot, \$5.30; 45-foot, \$6.90; 50-foot, \$9; 55-foot, \$15; 60-foot, \$18.

It will be seen that the values for lumber at \$18 and those for ties are nearly equal, with the advantage in favor of lumber. At \$24 per M, the values for lumber rise towards those for poles. The values for cordwood are very small, and show conclusively that it does not pay to make into wood any chestnut fit for other products.

VOLUME TABLES.

The tables which follow show the volumes in different kinds of materials for trees of different sizes, calculated from tables in the United States Forest Service Bulletin 96. These were based on measurements of 218 felled trees in Connecticut and adjacent portions of New York. Since the conditions of growth here are similar, these figures will apply to Massachusetts trees.

Since volume tables give the average of large numbers of measurements, they cannot be expected to be accurate for individual trees, but only for numbers of trees growing in well-stocked stands. To apply the tables, the number of trees of each inch diameter class should be ascertained by measurement or estimate. The average height of trees of each diameter should be taken to the nearest 10 feet. The total volume can then be found by multiplying the number of trees in each diameter class by the figure in the table for the corresponding height, and adding the products.

The figures published by the State Forester of Connecticut in 1906 are included in these tables for the purpose of comparison. These figures are set in heavy type. They are based on over 400 trees.

Cordwood.

Table 6 is computed from the Forest Service table of volume in cubic feet of round wood, and the table of converting factors — percentages of solid wood in stacked cordwood — to reduce these to cords. These factors are said to be conservative, which probably explains why the Connecticut figures are slightly larger than the corresponding ones calculated from the Forest Service bulletin.

TABLE 6. — *Volume of Chestnut in Cords.*

[Computed from tables in Forest Service Bulletin 96.]

Height in feet,	20.	30.	40.	50.	60.	70.	80.	90.
DIAMETER BREAST HIGH (INCHES).	Volume in Cords.							
2, ...	0.003	0.005	—	—	—	—	—	—
3, ...	.006	.01	0.01	—	—	—	—	—
4, ...	—	.02	.02, .02	0.03	—	—	—	—
5, ...	—	.02	.04, .04	.04	—	—	—	—
6, ...	—	—	.04	.06, .06	0.07	—	—	—
7, ...	—	—	.06	.07, .08	.09	—	—	—
8, ...	—	—	.07	.09	.11, .11	0.12	—	—
9, ...	—	—	.09	.11	.13, .13	.15	—	—
10, ...	—	—	.12	.14	.16, .17	.18	0.20	0.21
11, ...	—	—	.14	.17	.19, .21	.22	.24	.26
12, ...	—	—	.17	.20	.23	.26, .27	.29	.32
13, ...	—	—	.19	.23	.27	.30, .31	.34	.38
14, ...	—	—	—	.27	.31	.36, .34	.40	.44
15, ...	—	—	—	.30	.35	.41, .41	.46	.51
16, ...	—	—	—	.34	.40	.46, .47	.52	.58
17, ...	—	—	—	.38	.45	.52, .53	.59	.66
18, ...	—	—	—	.43	.50	.58, .61	.66	.74
19, ...	—	—	—	.46	.53	.64	.70, .73	.82
20, ...	—	—	—	.51	.61	.71	.77, .81	.92
21, ...	—	—	—	—	.68	.79	.86, .90	1.01
22, ...	—	—	—	—	.74	.86	.95, .99	1.11
23, ...	—	—	—	—	.80	.94	1.04, 1.07	1.21
24, ...	—	—	—	—	.88	1.03	1.14, 1.17	1.32
25, ...	—	—	—	—	.96	1.12	1.25, 1.28	1.44

Figures in heavy type are those in the Connecticut bulletin.

Lumber.

The volume table for lumber is adapted from that in the Forest Service bulletin. Logs were scaled by the International rule, reduced 10 per cent. to allow for the wide kerf of the ordinary portable mill. The volume of topwood and limbs has been reduced to cords by dividing by 80, a conservative factor.

The Connecticut figures were based on a modification of the Doyle rule, amounting practically to a mill-tally rule.

TABLE 7. — *Volume of Chestnut in Lumber and Additional Cordwood.*

[Computed from tables in Forest Service Bulletin 96.]

Height in feet, .	50.		60.		70.		80.		90.	
DIAMETER BREAST HIGH (INCHES).	VOLUME.									
	Board Feet.	Cords.	Board Feet.	Cords.	Board Feet.	Cords.	Board Feet.	Cords.	Board Feet.	Cords.
9, ...	10	.07	15, 35	.09	22	.10	-	-	-	-
10, ...	26	.06	32, 47	.08	40	.09	48	.09	56	.08
11, ...	42	.06	50, 60	.08	58	.09	69	.09	80	.09
12, ...	58	.06	68, 75	.08	78	.09	92	.09	107	.10
13, ...	74	.06	87, 91	.08	100	.09	116	.10	133	.10
14, ...	92	.06	107	.08	122, 110	.09	141	.10	160	.11
15, ...	110	.06	127	.08	147, 131	.10	168	.11	190	.12
16, ...	129	.06	150	.09	172, 155	.11	196	.12	222	.14
17, ...	-	-	174	.09	200, 180	.12	226	.14	255	.17
18, ...	-	-	198	.09	227, 206	.12	257	.16	291	.19
19, ...	-	-	223	.09	257, 235	.13	292	.17	328	.21
20, ...	-	-	250	.09	288, 266	.14	327	.19	368	.24
21, ...	-	-	276	.10	318, 298	.16	363	.21	409	.27
22, ...	-	-	305	.10	350, 335	.17	400	.24	451	.30
23, ...	-	-	333	.11	385, 372	.19	440	.27	493	.34
24, ...	-	-	363	.11	420, 411	.21	479	.30	538	.39
25, ...	-	-	396	.12	457, 451	.23	520	.34	583	.45
26, ...	-	-	-	-	495	-	-	-	-	-
27, ...	-	-	-	-	541	-	-	-	-	-
28, ...	-	-	-	-	587	-	-	-	-	-
29, ...	-	-	-	-	637	-	-	-	-	-
30, ...	-	-	-	-	688	-	-	-	-	-

Figures in heavy type are those in the Connecticut bulletin.

Ties.

Table 8 gives the contents of trees in 6 by 8 inch ties, with the wood left in tops and limbs. The Connecticut figures run lower than those of the Forest Service.

TABLE 8. — *Volume of Chestnut in 6 by 8 Inch Ties and Additional Cordwood.*

[Computed from tables in Forest Service Bulletin 96.]

Height in feet, . .	50.		60.		70.		80.		90.	
DIAMETER BREAST HIGH (INCHES).	VOLUME.									
	Ties.	Cords.	Ties.	Cords.	Ties.	Cords.	Ties.	Cords.	Ties.	Cords.
10, ...	1	.11	1, 1	.13	1	.14	1	.13	3	.12
11, ...	1	.10	1, 2	.12	2	.13	2	.13	4	.12
12, ...	2	.09	2, 2	.11	3	.13	3	.13	4	.13
13, ...	3	.09	3, 3	.10	3	.12	4	.12	5	.13
14, ...	3	.08	3	.10	4, 5	.12	5	.12	8	.13
15, ...	5	.08	5	.09	4, 5	.12	6	.12	9	.13
16, ...	6	.07	6	.09	5, 7	.11	7	.13	9	.14
17, ...	-	-	6	.08	5, 8	.11	8	.13	10	.16
18, ...	-	-	7	.07	8, 6 ¹	.12, .09	9	.14	11	.17
19, ...	-	-	7	.07	8, 7 ¹	.12, .09	10	.15	12	.19
20, ...	-	-	8	.06	10, 8 ¹	.12, .10	11	.17	13	.22
21, ...	-	-	9	.06	10, 9 ¹	.13, .10	11	.18	14	.24
22, ...	-	-	11	.06	10, 10 ¹	.14, .11	14	.21	17	.27
23, ...	-	-	12	.06	12, 11 ¹	.15, .12	14	.23	17	.31
24, ...	-	-	12	.06	13, 13 ¹	.16, .13	15	.27	19	.36
25, ...	-	-	15	.06	15, 14 ¹	.18, .14	18	.30	21	.42
26, ...	-	-	-	-	16 ¹	.15	-	-	-	-
27, ...	-	-	-	-	18 ¹	.16	-	-	-	-

Figures in heavy type are those in the Connecticut bulletin.

¹ Seventy-five feet in height.

Poles.

Table 9 gives the length of pole that can be obtained from trees of different dimensions, with the volume in cords of additional wood. The Connecticut figures agree exactly with the corresponding ones of the Forest Service.

TABLE 9. — *Volume of Chestnut in Poles and Additional Cordwood.*

[Computed from tables in Forest Service Bulletin 96.]

Height in feet, ...	50.		60.		70.		80.		90.	
DIAMETER BREAST HIGH (INCHES).	VOLUME.									
	Length of Pole.	Cords.	Length of Pole.	Cords.	Length of Pole.	Cords.	Length of Pole.	Cords.	Length of Pole.	Cords.
12, ...	-	-	25, 25	-	-	-	-	-	-	-
13, ...	25	.04	25, 25	.08	25	.12	25	.15	25	.18
14, ...	30	.02	30	.06	30, 30	.11	30	.14	30	.17
15, ...	35	-	35	.04	35, 35	.10	35	.13	35	.16
16, ...	-	-	-	-	40, 40	.08	40	.11	40	.14
17, ...	-	-	-	-	40, 40	.10	45	.10	45	.13
18, ...	-	-	-	-	45, 45	.06	50	.09	50	.11
19, ...	-	-	-	-	45 ¹	-	-	-	55	.10
20, ...	-	-	-	-	45 ¹	-	-	-	60	.09
21, ...	-	-	-	-	50 ¹	-	-	-	-	-
22, ...	-	-	-	-	55 ¹	-	-	-	-	-
23, ...	-	-	-	-	55 ¹	-	-	-	-	-
24, ...	-	-	-	-	55 ¹	-	-	-	-	-
25, ...	-	-	-	-	55 ¹	-	-	-	-	-
26, ...	-	-	-	-	55 ¹	-	-	-	-	-
27, ...	-	-	-	-	55 ¹	-	-	-	-	-
28, ...	-	-	-	-	55 ¹	-	-	-	-	-
29, ...	-	-	-	-	55 ¹	-	-	-	-	-
30, ...	-	-	-	-	-	-	60	-	-	-

Figures in heavy type are those in the Connecticut bulletin.

¹ Seventy-five feet in height.

LIST OF OPERATORS MAKING A SPECIALTY OF HANDLING CHESTNUT.

This list makes no pretence to be complete, especially since the Boston & Maine and the New York, New Haven & Hartford furnished no information on this point, but it includes all the dealers handling chestnut of whom this office knows.

Massachusetts.

Amherst:	Hudson:
Cadwell, F. A.	Robertson & Larkin.
Athol:	Huntington:
Paige & Farrington.	Fisk, M. R.
Bernardston:	Lee:
Chapin, John W.	Hopkins, D. D.
Burrows, Baxter.	
Boston:	Leicester:
Bates, Willis C., Company.	Southwick & Barry.
Hurd, J. A., Lumber Com- pany.	Leyden:
	Barber & Chapin.
Chester:	Ludlow:
Brown, G. H.	Burr, F. L.
Enfield:	Montague:
Hamilton, F. E.	Lyman, F. L.
Erving:	Montgomery:
Reynolds, Henry.	Camp, M. E.
Granville Center:	North Amherst:
Frisbie, N. M.	Cowls, W. D.
Great Barrington:	North Brookfield:
Davis, Warren H.	Fullam, W. F.
Stevens, George A.	Cummings, H. E.
Greenfield:	North Leverett:
Porter, H. C.	Cadwell & Glazier.
Hampden:	North Wilbraham:
Carew, N. M.	Green, H. M.
Thresher Bros.	
Temple, E. H.	

Northampton:

Bailey, S. A.

Northborough:

Mentzer, T. E.

Falvey, Wm. H.

Northfield:

Aldrich, F. E.

Aldrich & Shipman.

Norton:

Sweet, A. H., & Son.

Sweet, A. E. & C. W.

Oxford:

Turner Bros.

Chaffee Bros.

Palmer:

Allen, J. M.

South Berlin:

Wheeler, W. E.

Southampton:

Parsons, E. K.

Southbridge:

Ide Lumber Company.

Spencer:

Wilson, Wm. A.

Springfield:

Hurwitz, Samuel.

Potter & Bartlett.

Sterling:

Wilder, Walker & Davis.

Wales:

Needham & Hubbard.

Ware:

Moore, John H.

Coney, A. N.

Warren:

Shepard, H. N.

Warwick:

Williams, Chas. A.

Westfield:

Allen, Mrs. J. F.

Bodurtha, S. H.

Ely Bros.

Hallbourg, Frank & Son.

Peck & Marcoullier.

Loomis, George W.

Bosshart, H. A.

Frazier & Joslin.

Worcester:

Arnold, F. A.

Bagdasarian, M.

Jacques, George L.

Luce, Charles T.

Other States.

Cumberland Hills, R. I.:

McLaughlin, John.

Eagleville, Conn.:

White, J. M.

Norwich, Conn.:

Brockett, L. B.

Potter, A. L., & Co.

Suffield, Conn.:

Stiles, W. L.

Thompsonville, Conn.:

Woodworth, I. D.

THE "WILT DISEASE," OR "FLACHERIE,"

OF

THE GYPSY MOTH.

BY

WILLIAM REIFF,

BUSSEY INSTITUTION OF HARVARD UNIVERSITY.

UNDER THE DIRECTION OF

F. W. RANE, STATE FORESTER.



BOSTON:

WRIGHT & POTTER PRINTING COMPANY, STATE PRINTERS,
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1911.

THE "WILT DISEASE" OR "FLACCHERIA"

THE CYPRESS MOOTH

WILLIAM RILEY

INSECT PATHOLOGIST OF HARVARD UNIVERSITY

LEAFHOPPER

E. W. RABBIT STATE FORESTER

APPROVED BY
THE STATE BOARD OF PUBLICATION.



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INTRODUCTORY.

Anything that offers promise of being effective in our warfare against the gypsy moth is hailed with delight by our Massachusetts people.

It is with pleasure that the State Forester is able to offer this publication, setting forth the work with the "wilt disease," or "Flacherie," of the gypsy moth, which has been carried on during the past two years by Mr. William Reiff, under the supervision of Prof. W. M. Wheeler of the Bussey Institution of Harvard University. Professor Wheeler's co-operative interest in the moth-suppression work in the State is highly appreciated by the State Forester, and the results shown in this bulletin will prove, we are sure, of great interest generally.

This bulletin is a companion, in a way, to that issued on parasites, in that it is another method of attacking our foe. We desire to have as many strings as possible to our bow in fighting this pest. That this "wilt disease" is a most hopeful remedy there is little question. We anticipate carrying on even more extensive work with it the coming season.

Upon reading this bulletin it will be readily apparent that any one can easily assist in furthering this work at little, if any, expense; and it is to be hoped that many will not only acquaint themselves with the methods employed, but experiment on their own initiative. If the State Forester can assist you in any way do not hesitate to call upon him.

ACKNOWLEDGMENTS.

The experimental work and writing up of the data in this bulletin was done by Mr. William Reiff of the Entomological Laboratory of the Bussey Institution of Harvard University.

The State Forester decided that the work undertaken by Mr. William Reiff during the season of 1909 was well worthy

of being continued upon a much larger scale, and co-operative plans were happily agreed upon with Dr. Wheeler, with the results as outlined in this bulletin.

Besides Professor Wheeler and Mr. Reiff, there are the field agents and local superintendents of the regular moth staff, who made it possible to get results. To these we are also under obligations for their loyal support and co-operation.

F. W. RANE,

State Forester.

Boston, Mass., March 21, 1911..

THE "WILT DISEASE," OR "FLACHERIE," OF THE GYPSY MOTH.¹

I. Caterpillär Diseases in General.

The production of diseases is one of nature's methods of quickly checking the overproduction of living things. Animals, including man, and plants all have their own specific infectious diseases, which usually appear whenever a species becomes so numerous that it menaces the prosperity of the coming generations. In the animal kingdom the possibility of overproduction is especially apt to occur in insects, since they form by far the largest portion of the world's fauna, and have a high rate of reproductivity. Insects, small though they are individually, form in their totality an immense mass of living matter. Of this mass we can get only a slight conception, even when we consider that insects are everywhere present, not only as a few scattered individuals, but in such enormous numbers that they constitute, as it were, a world in themselves. We may say without hesitation that among all the conditions which arise from and are caused by animals, there is none more widely distributed, more many-sided and which interferes more deeply with life on our planet than that which is brought about by insects. As Graber says:—

Man may unwisely neglect these creatures — as he does many things; but their power for evil crushes him the more; indeed, it may destroy him if he persists in his neglect.

Now, such a power may be checked by nature by one of the most efficient means which she possesses, — the infectious diseases.

Owing to the profound influence which insects exert upon us and our culture, attention has been drawn to their diseases. A close study has been made of some of these; especially of

¹ Contributions of the Entomological Laboratory of the Bussey Institution, Harvard University, No. 36.

those known to occur in the silkworm (*Bombyx mori*) and in the "nun" moth (*Psilura monacha*), which latter destroys the forests of Central Europe.

The first scientific knowledge which we have of caterpillar diseases we owe to the valuable investigations of the French scientist Pasteur. Since his time many other investigators have been engaged in this study, among them the Germans Standfuss and Emil Fischer, the Italians Verson and Bolle, and the Americans Snow and Forbes. By their experiments and investigations we are now able to recognize the character of the more common caterpillar diseases.

We may mention some of those diseases with which the lepidopterist will come in contact in the course of a few years.

A very frequent disease of caterpillars is the *common diarrhœa*, which is produced in most cases by too juicy or too wet food. This is shown by the unusually wet excrement, the fluid part of which is green. If the disease is of longer standing, the excrement does not cling together, but is voided as a pulpy mass, in which the single vegetable particles swim around undigested. This disease in itself is not dangerous, since it is not infectious, but it may prepare the way for the attack of other infectious diseases, which will be mentioned further on.

In another disease, which has no popular name as yet, and which I shall call *bead disease*, the excrement masses hang from the body like a string of beads. This intestinal disease is probably due to unhealthy food, but the specific cause has not been determined. Apparently this disease, too, is not infectious.

Of much greater importance is the disease known as *muscardine*. This is really a collective name for a series of fungous diseases, which convert the infected caterpillar in a short time into a stiff, swollen mass, with the skin invested with a grayish-white coating. Very hairy caterpillars are especially susceptible to muscardine, but in extremely wet years even smooth caterpillars suffer from fungous diseases. It is easy to determine whether muscardine is present in a given locality because the diseased caterpillars crawl toward the exposed tops of grass blades, poles or stems, and remain there after death, thus be-

coming visible for a considerable distance. On a trip which I made in June, 1910, to Raymond, N. H., I saw thousands of brown-tail moth caterpillars dead from muscardine, and commonly hanging in this characteristic manner. Since these fungous diseases are extremely infectious, and propagate with incredible swiftness, and since healthy caterpillars are much inclined to gnaw at dead ones, the artificial production and propagation of muscardine has been hopefully considered during the last few years as a means of destroying the brown-tail moth.

There are two fungi, especially, which are responsible for the death of most caterpillars; these are *Botrytis bassiana* Bals and *Entomophthora aulicæ* Reichhardt. Experiments with fungous diseases of the brown-tail moth are being conducted by Mr. A. T. Speare, under the direction of Dr. R. Thaxter of Harvard University.¹

The *pébrine* or *pebrina*, which has become so notorious through the great damage it has caused to the silk industry, is the caterpillar disease which has been studied so far most thoroughly. Caterpillars with this disease always have a wet anus, and if they are hairy, the hairs on this region of the body stick together. Smooth caterpillars also change their color considerably; for instance, green caterpillars turn yellowish, and are often mottled with dark, irregular spots; gayly colored caterpillars lose their brilliancy. This disease does not kill in a few hours or days, but the infected caterpillars languish slowly, lose their appetite, and become transparent and ill-nourished. They then shrink more and more, till finally at death only the flabby dry skin remains. Pébrine appears preponderatingly in wet years, and its cause seems to be lack of nourishment. The specific cause, however, the disposition, has not yet been absolutely determined. The carriers of the disease are known under the name *Corpuscoli di Cornalia*, and have been described by Lebert² as the fungus *Panhistophyton ovatum* (*Micrococcus ovatus*). Here it might be of interest to cite from a review in "Deutsche Entomologische

¹ "Seventh Annual Report of the State Forester of Massachusetts," 1910, pp. 98-101.

² "Berliner Entomologische Zeitschrift," 1858, p. 170.

National Bibliothek," No. 3, Jahrg. II., 1911, where it is stated that the botanist Naegeli described the carrier of the pébrine, as early as 1857, as *Nosema bombycis*. This review, moreover, mentions the fact that W. Stempell (38. Jahresber. Zool. Sekt. Westf., Prov. Ver. f. Wiss. u. Kunst, 1909-10, p. 37) has made artificial infection experiments with this parasite, and found that it develops with extreme rapidity and great virulence, not only in caterpillars of the silkworm, but also in caterpillars of several local species of the same family. Thus Stempell reached the conclusion that this susceptibility of the individuals towards the pébrine parasite might be used practically in combating injurious caterpillars. He further mentions that his researches on this and other *Microsporidia* are of biological interest, since it would seem that there must be organisms so minute that they cannot be seen, even with our most modern optical instruments. In several infectious diseases the carriers of the disease have not yet been optically demonstrated, and it may be that these carriers are such small organisms. These little oval shining bodies are now no longer regarded as plant organisms, but as belonging to the *Psorospermii*, a group of Protozoa. Pébrine is extremely infectious, and is carried over, as Pasteur has proved, from generation to generation in the eggs, with increasing destructiveness.

We come now to the last and probably most important of all the common caterpillar diseases, the disease called *Flacherie*, *Flaccidenza* or *caterpillar cholera*, and in America known also under the name "wilt disease." This disease is characterized as follows: a caterpillar suffering from it soon stops eating, becomes weak and lazy, and usually crawls up on some object, as the trunk of a tree, a fence, a wall, or other vertical surface, where it remains without motion. In a few hours there drops from its mouth and anus a dirty, blackish, foul-smelling liquid; the caterpillar becomes more and more flaccid, one leg after the other loses its support, and finally the creature, reduced to a black skin, hangs dead, still holding on with one or two of its false feet or with the anal claspers. The slightest touch now suffices to break the skin, and a thin, dark, offensive-smelling

liquid flows out. Flacherie kills the older more quickly than the younger caterpillars. Young caterpillars, indeed, often live several days before they are killed by the disease. It is not positively known what organisms produce Flacherie. The bodies of caterpillars which have died of this disease show extremely small bacilli, innumerable schizomycetes, and, more particularly, many small strings of micrococci; but which of these micro-organisms, if any, is the real carrier of the disease is still unknown to specialists.¹ To the investigations of Dr. E. Fischer, in Zürich, Switzerland, we owe considerable information regarding the primary causes leading to Flacherie, and the manner in which the disposition to this disease may be induced. He has pointed out that a decrease in the nutritive value of the food of the caterpillars, which induces a disturbance in their metabolism, is the first condition leading to the contraction of the disease. As a result of these disturbances the organisms responsible for the disease immediately find conditions suitable for their growth. One of the main causes of the disease is therefore to be sought in the predisposition of the caterpillars, while the specific infection of Flacherie is to be regarded as coming more or less secondarily; in other words, without this predisposition infection cannot take place, and the predisposition can be brought about artificially by insufficient nourishment.² Flacherie seems to be influenced by climate and weather conditions less than any other caterpillar disease. We meet with it both in the old and the new world, in wet, in dry and in normal weather. As a result of its comparatively great abundance and its extremely easy infection, Flacherie has become the "guardian angel" of the Central European forests. When the "nun" (*Psilura monacha*) makes its appearance in some places in Europe in vast numbers, man with his wit and the powerful means at his command is quite unable to stop the destruction, but Flacherie always comes to his assistance. Although this disease has been much studied, it has not yet been positively

¹ Very recently C. Sasaki, in Tokyo, Japan, found that there were also polyhedral corpuscles present in caterpillars which were sick from Flacherie ("Deutsche Entomologische National-Bibliothek," Jahrgang II., 1911, No. 1, Referat). Since polyhedral corpuscles, however, are found chiefly in caterpillars which have been infected by the pébrine, a close relationship of these two diseases is highly probable.

² See Fischer's detailed accounts in the "Biologisches Centralblatt," Band XXVI., No. 13-16. Leipzig, 1906.

established whether it is hereditary or not. There is at present no argument that can be brought against the heredity of the disease, while there are some important facts which indicate its heredity. These will be considered later.

II. *Résumé* of Some Experiments with Flacherie in 1909.

Fischer called attention, in his excellent paper, already mentioned, to the manner in which Flacherie can be artificially developed. He says that the disposition to the disease is secured by giving the caterpillars food which has been placed in water and renewed only every three or four days. This treatment apparently causes an injury to the leaf protoplasm, due to the presence of too much water, and there is a concomitant increase in the acidity of the leaves.¹ If, now, a caterpillar eats such leaves, the alkalinity of its digestive fluid, which is very strong in healthy individuals, decreases, and in this manner the first susceptibility to the disease is given. Before the visible outbreak of Flacherie, Fischer could recognize as an early symptom a characteristic sweet odor in the breeding cages, which could be compared best to that of somewhat withered lilac blossoms. Whenever this odor was noticeable Flacherie soon made its appearance, and as it progressed the odor increased proportionately. Fischer recommends the artificial production of Flacherie among the caterpillars of the "nun" ("die Nonne" of the Germans) by intentionally giving the larvæ this kind of food as soon as an abundance of the pest is noted in any particular locality.

Bearing in mind the close relationship existing between the "nun" and the gypsy moth, I attempted during the summer of 1909 to put Fischer's conclusions regarding the artificial production of the wilt to a practical test. These experiments were published in detail in the entomological journal "Psyche," Vol. XVI., No. 5, October, 1909. There appeared also a German translation of the paper in the "Societas Entomologica," Jahrgang XXIV., pp. 178-181, Zürich, Switzerland. The main facts in these experiments are here noted. Up to 70 per cent. of the caterpillars were killed by artificially produced

¹ See the experiments which Sasaki performed on mulberry trees in Japan, "Zeitschrift für Pflanzenkrankheiten," XII. Band, Jahrgang 1902, 4. Heft, pp. 203-226; 5. Heft, pp. 258-278.

Flacherie, while all caterpillars which were kept apart for control remained healthy. From these results I was therefore led to believe that the artificially produced Flacherie might be utilized as a valuable aid in the destruction of gypsy moth caterpillars. If the disease appears in nature during normal weather conditions, the caterpillars are in most cases almost full grown when attacked; but the farther the weather conditions of the year differ from the normal, the earlier in their life will the disease affect them. The fact that I succeeded in rendering the caterpillars susceptible to the wilt before the third molt suggested that this may be of importance in the practical use of the disease, since by artificially inducing Flacherie, relief might be had weeks sooner than happens in nature.

Better to understand the conclusions drawn from the last experiment, which was performed on trees on which a considerable number of gypsy moth caterpillars occurred naturally, the following account is given: A group of oak and another of willow trees were infested with about 5,000 caterpillars each. Shortly before their fourth molt, upon each of these two groups of trees 100 sick and 50 dead caterpillars were distributed. The disease spread with amazing rapidity, and even on the following day many freshly killed caterpillars could be counted. By the time of pupation about 4,000 caterpillars on each group of trees had succumbed to the disease. Two conditions which did not enter into my previous experiments united to cause this unusual result. In the first place, the two groups of trees had been badly infested and injured by gypsy moth caterpillars the previous season, as was evidenced by the unhealthiness of the leaves during the summer of 1909, and the caterpillars had probably become predisposed to the disease on account of the resulting decrease in the value of their food. As a second very important factor may be mentioned the dry weather, which by its desiccating effect upon the leaves served to render the food for the caterpillars still less nutritious. Hence, from the beginning there was a decreased vitality in the tissues, and digestion was early disturbed. In short, the caterpillars were already very susceptible to the disease at the time I introduced it

among them, and conditions were therefore most suitable for the spread of the wilt. Always in the places that have been injured by gypsy moth caterpillars in previous years, there is a predisposition on the part of caterpillars of the following year toward Flacherie. The heavy defoliation checks the normal metabolism of the attacked vegetation, which causes a weak and sickly development of the shoots, and these therefore do not furnish the caterpillars sufficiently wholesome nourishment. It should be remembered that these facts, in the long run, mean a self-protection of the vegetation. If at this time dead and sick material is introduced among the caterpillars in such a locality, the organisms of the disease will act readily upon the individuals present. Infection will take place even in cases where a locality is badly infested by the caterpillars for the first time, because one can always find a large number of weak and therefore susceptible specimens. Then, as the disease progresses, it acquires such virulence that even the previously healthy specimens become infected.

In the article mentioned I called attention to other ways in which the caterpillars advance the infection among themselves, that is, during the resting period, during the feeding time, etc., and how easily the disease may be carried over by the caterpillar to its pupal stage. The great probability of an economic value in Flacherie for destroying the gypsy moth was suggested, but it was thought that the experiments of only a single year had better not be taken as a comprehensive method for the practical use of the wilt, and that further experiments should be undertaken on a larger scale to substantiate the obtained results.

III. Flacherie Experiments in 1910.

A. GENERAL.

In the spring of 1910 the author was requested, by the State Forester of Massachusetts, to make similar experiments on a large scale in different parts of the State.¹ These experiments were undertaken with the help and kind encouragement of Prof. W. M. Wheeler. I would also express my indebtedness

¹ Cf.: "Sixth Annual Report of the State Forester of Massachusetts," 1909, p. 86.

to all those from whom I have received advice and actual assistance. My thanks are also due to State Forester Frank W. Rane and Assistant Forester L. H. Worthley for much help; and to their division agents, Norman Souther of Bridgewater, and Francis C. Worthen of Georgetown, and to Mr. H. P. Richardson, local moth superintendent of Concord, for their support in the field work. Last but not least, I owe, through correspondence, several valuable hints to Dr. E. Fischer, Zürich, Switzerland, who, through his investigations on insect diseases, is to be regarded the proper instigator of these experiments.

In the beginning of the work each of the division agents was asked by letter to suggest convenient localities in which to conduct the experiments. Three of the division agents stated that they had no suitable places in their districts. In the remaining divisions 29 places were chosen, but at the end of my investigations unfortunately 13 of these could not be used, since some of the local moth superintendents had not followed instructions, and other places had been sprayed with arsenate of lead. Isolated forest districts, varying from small areas to several acres, were chosen for the experiments. The isolation was for the purpose of making easier a control of the place, since in such a locality an eventual increase or decrease of the caterpillar mass by migration was less probable. The local superintendents of the different places were instructed not to use any artificial means for destroying caterpillars in the selected woods. I was, however, obliged to use some localities in which, during the preceding winter, some of the egg clusters had been killed by creosote. According to the size of the various places, the local superintendents were requested to collect a corresponding mass of gypsy moth caterpillars shortly before their second molt. These amounted to from 50 to 100 individuals per acre. Where many egg clusters were present but few caterpillars had to be collected, and *vice versa*. Hence, the number of caterpillars to be collected was decided in advance for each locality. The reason for this is that an infection spreads more easily and rapidly in a heavily infested district than in places less damaged by caterpillars. In a

badly infested forest of 10 acres or more the average number of caterpillars to be collected was placed at less than 50 specimens per acre, since the disease spreads best in such localities.

The local superintendents had been instructed to feed the collected caterpillars daily with oak leaves, or with apple leaves where oak leaves could not be secured. These leaves were not to be removed from the twigs, and were to be placed in water for at least four days before feeding. A special emphasis was laid on not giving as food leaves of trees which had been sprayed with arsenate of lead. As breeding cages common wooden boxes were used, to which the entry of air was provided for by means of gauze coverings. Further, the local superintendents, who were not familiar with the wilt, were taught the character of this disease and its manner of appearance, and were instructed to communicate with me at once on the first appearance of *Flacherie* in their breeding cages. The local superintendents were asked to attend to this part of the work, since at that time it was not convenient to rear several thousand gypsy moth caterpillars in one place, and also in order that their interest might be awakened in the experiments.

As soon as the wilt was determined to be present in a brood the whole material was transplanted upon the previously chosen places, with the help of the respective superintendents. This was done as follows: a piece of clean cloth, burlap, for instance, about 2 feet long by 1 foot wide, was hung in dense foliage between the limbs of a tree, or from one tree to another close by (Fig. 1). In this hammock-like bag were placed, besides the dead and still living caterpillars of the brood, also all food remaining in the breeding cage, since such remains might also be supposed to contain organisms of the disease. No means were used to prevent the escape of the sick but still crawling caterpillars, in order that they might disseminate the organisms.¹ Where possible, the bag with the material was hung about 6 feet or still higher from the ground, in order that the wind might aid in the spread of the disease. In planting the diseased material the direction of the prevailing wind of the

¹ That this is the case is proved by some experiments which I shall consider particularly later, where only sick caterpillars were transplanted, but no dead caterpillars.

season was taken into consideration. For instance, in localities which had prevailing east winds the infected material was exposed near the eastern border of the forest, but still inside of it, so that the wind, before reaching the larger part of the wood, was forced to strike first the center of the diseased area. It may be mentioned that in some cases, where no convenient cloth was at hand, the breeding cages themselves with the material, after the removal of the cover, were hung between limbs. No difference was observed in the results. The infected material was planted in most of the localities at a time when most of the caterpillars in the field were undergoing the

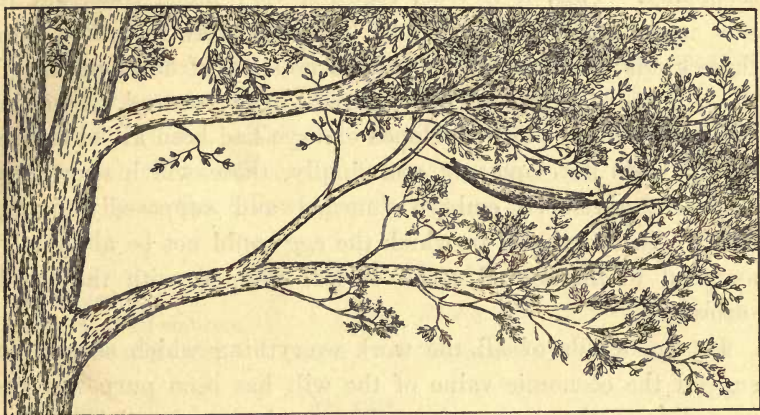


Fig. 1.—Method of hanging hammock in tree.

third molt. The respective ages of the caterpillars will be mentioned under each experiment.¹

It was important to select places which gave the best guarantee for the health of the growing caterpillars; hence, special attention is called to the fact that in the experimental localities no disease is known to have occurred among the caterpillars of previous years.

¹ I had always planned to plant the disease as soon as it made its appearance in one or the other of the broods. This was, however, frustrated on several occasions by various circumstances. For instance, some local superintendents did not notice the Flacherie till after the disease had prevailed for several days. It was, further, not always possible for me to depart immediately upon receiving a communication concerning the outbreak of the disease. It was also almost impossible for one man to transplant the infected material to all the chosen places during the short time in which the gypsy moth caterpillars were in the third or beginning of the fourth stage. This is the reason why in some localities the disease was planted later, although the caterpillars were already beyond the third molt.

After the eggs were laid in the autumn of 1910 all localities were carefully inspected, and the number of the fresh clusters was determined as nearly as possible. For examination of the single eggs, five clusters, when possible, were collected from each locality. Five clusters from a place in the western part of Concord, Mass., served for control. These eggs must be considered as normal because they come from a place in which positively no disease whatever has occurred. In collecting clusters for examination the first five found were taken; and were not taken at random.

Every single egg of all these clusters was examined microscopically. This, it is true, required very much time, but it was nevertheless indispensable. The eggs were separated into three kinds: first, those that showed no signs of development of the embryo (empty or unfertilized eggs); second, those in which the more or less developed embryo had been killed before its complete development; and finally, those which showed a perfectly developed embryo (normal and supposedly living eggs). In every case in which the egg could not be absolutely assigned to the second series it was counted with the third series.¹

In the details of all the work everything which seemed to suggest the economic value of the wilt has been purposely regarded from the most unfavorable standpoint, for the purpose of meeting any objections. When estimating the egg clusters from the selected localities there was always present either the division agent or the local superintendent, and at that time written notes were made of these estimates before the introduction of the disease. In the spring we made the lowest possible estimate on the number of clusters present, while with the second estimate in the autumn, after the disease had produced its effect, the fresh clusters were estimated as liberally as possible.

The average which resulted from the examination of the single clusters must not be taken as absolutely fixed, since the small number of the clusters examined admits of a variation

¹ The eggs of the control clusters could all be distributed with exactitude into the respective series.

from the mean in both directions. The main purpose of the experiments, however, was not to make mathematically exact calculations, but to find out in what manner and to what degree the gypsy moth may be infected by the wilt. For these purposes the calculations made should be sufficient, and the figures given will not be far from the real average.

As to the control experiment, the average of eggs in a normal cluster was found to be 437. I am not aware that the eggs of a large series of normal clusters have ever been counted in order to establish an accurate average. In published reports the average of eggs in a normal cluster is stated as "400 to 500."

Control Experiment, Concord, Mass.

Five clusters were taken in the western part of this locality, where there certainly did not occur any disease among the gypsy moth caterpillars. These clusters, therefore, must be regarded as normal. The microscopic examination of the eggs of these clusters gave the following results:—

Cluster 1.

Unfertilized eggs, . . .	1	} = .73 per cent., or about 1 per cent.
Eggs with dead embryos, . .	3	
Eggs apparently alive, . . .	543	
Total, . . .	547 eggs.	

Cluster 2.

Unfertilized eggs, . . .	-	} = .47 per cent., or about .5 per cent.
Eggs with dead embryos, . .	2	
Eggs apparently alive, . . .	424	
Total, . . .	426 eggs.	

Cluster 3.

Unfertilized eggs, . . .	3	} = 1.74 per cent., or about 2 per cent.
Eggs with dead embryos, . .	4	
Eggs apparently alive, . . .	395	
Total, . . .	402 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = .93 per cent., or about 1 per cent.
Eggs with dead embryos, . .	3	
Eggs apparently alive, . . .	424	
Total, . . .	428 eggs.	

Cluster 5.

Unfertilized eggs, . . .	-	}	=	.79 per cent., or about 1 per cent.
Eggs with dead embryos, . .	3			
Eggs apparently alive, . .	377			
Total, ...	380	eggs.		

The average of these 5 clusters is as follows: —

Dead eggs, ...	4	=	.92 per cent., or about 1 per cent.
Eggs apparently alive, . .	433	=	99.08 per cent., or about 99 per cent.
Total, ...	437	eggs.	

The results of this control experiment are used in estimating the departure from the normal of the egg masses in all the other experiments.

B. THE SINGLE EXPERIMENTS.

Concord, Mass.

Division Agent, CHAS. W. MINOT; Local Superintendent, HENRY P. RICHARDSON.

As a suitable place for my experiments, I located, on May 20, 1910, an isolated forest of about $2\frac{1}{4}$ acres, belonging to the estate of Mr. William Brewster. This place is situated in the eastern part of Concord, about half a mile west of the West Bedford railroad station. The forest consists mainly of oaks about twenty years old and of a group of pines about fifty years old, all mixed with brush; and along the border, especially on the northern part, are birches about ten years old.

According to the local superintendent and to the owner, Mr. Brewster, the gypsy moth caterpillars were quite numerous during the summer of 1909. Both are certain that there was no disease among the caterpillars. We estimated this place to contain about 10,000 clusters of eggs in May, 1910.

On June 6 I received notice from the local superintendent that the wilt had appeared among the caterpillars which he had collected and fed according to instructions. Two days later I went to Concord, and found that some 10 caterpillars were already dead and the others were apparently very sick, as they remained motionless even when irritated. The superintendent had begun to feed the caterpillars on May 26, and had noticed the first dead specimen on June 5. Accordingly, he had succeeded in developing the wilt artificially in the course of eleven days.

With the assistance of the local superintendent the whole breeding material was immediately exposed in the western part of the selected forest. The distance from the ground to the material, which was hung between the limbs of a tree, was about 15 feet. The largest number of gypsy moth caterpillars in this locality were at this time in the third molt, or about to pass into this molt. The wilt soon spread over the whole forest, as was seen during occasional visits to the place by Mr. Richardson, Mr. Brewster and myself. On Sept. 7, 1910, the fresh egg clusters were estimated by the local superintendent and myself to amount to about 5,000. Often 4 or 5 of these clusters together would not make more than 1 normal cluster; the actual number of eggs was thus much less than would have been present in the same number of normal clusters.

The examination of 5 clusters which had been collected Sept. 7, 1910, on Brewster's estate showed the following counts:—

Cluster 1.

Unfertilized eggs, . . .	3	} = 9.66 per cent., or about 9.5 per cent.
Eggs with dead embryos, . .	11	
Eggs apparently alive, . . .	131	
Total, ...	145 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 7.43 per cent., or about 7.5 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . . .	137	
Total, ...	148 eggs.	

Cluster 3.

Unfertilized eggs, . . .	13	} = 48.06 per cent., or about 48 per cent.
Eggs with dead embryos, . .	49	
Eggs apparently alive, . . .	67	
Total, ...	129 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 8.64 per cent., or about 8.5 per cent.
Eggs with dead embryos, . .	6	
Eggs apparently alive, . . .	74	
Total, ...	81 eggs.	

Cluster 5.

Unfertilized eggs, . . .	-	} = 6.76 per cent., or about 6.5 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . .	69	
Total, ...	74 eggs.	

Averaging these 5 clusters we have:—

Dead eggs, ...	20	=17.24 per cent., or about 17 per cent.
Eggs apparently alive, . .	96	=82.76 per cent., or about 83 per cent.
Total, ...	116 eggs.	

A normal egg cluster contains on an average 433 eggs (p. 20) which are apparently alive. Since the infested locality averages only 96 eggs which are apparently alive per cluster, $4\frac{1}{2}$ clusters are necessary to equal the size of a normal cluster. The number of the fresh clusters, estimated at 5,000, thus has to be reduced to about 1,100 clusters to compare with the 10,000 clusters present in the spring of 1910. The number of apparently vital eggs, therefore, is decreased to about 11 per cent. through the action of *Flacherie*.

The local superintendent informed me that the disease had also spread into the neighboring forest districts. By an extended walk through about 5 acres of these woods I learned that the wilt had operated in the same manner as in the first locality. He is of the opinion that the number of clusters in this 5 acres has been decreased to about 15 per cent. Adjoining these woods there are about 15 acres of forest, in which the local superintendent found that all egg clusters which had been laid in the summer of 1909, and which had been deposited 1 foot or more above the ground, had failed to produce caterpillars, that is, the eggs had remained unhatched; but the caterpillars had all emerged from those eggs in clusters placed less than 1 foot above the ground. I found that these statements corresponded very closely with the facts. Here and there I noticed a slight exception by occasionally finding either a high-placed cluster from which a few caterpillars had emerged, or I detected close to the ground a cluster from which only a portion of the caterpillars had emerged. These exceptions, however, were insignificant, for they represented in each case hardly more than 10 eggs. I am unable, so far, to find any explanation for this peculiar occurrence. At first I thought that an egg parasite might have exerted its helpful power, but the examination of eggs from several clusters which had remained unhatched showed that almost all eggs contained a fully developed dead embryo, and no signs of a parasite could be found. The moisture of the soil cannot be made responsible, for bor-

dering this forest there is another with exactly the same soil, the same kind of trees and of the same age as the other place, and although these forests are separated only by a very broad road, in the latter wood the caterpillars of almost all egg clusters of 1909 had emerged from clusters that had been placed at any height on the trunks of the trees. There were exceptional cases of clusters, sometimes on the upper, sometimes on the lower part of the trees, from which all caterpillars had not emerged, but there was no evidence of the peculiar condition that characterized the clusters in the place first mentioned. Whether any caterpillar disease has any effect in this occurrence, I cannot now say. The solution of this question may come in the future from careful observations at this particular locality.¹

An extensive forest in the southwestern part of Concord was visited, in which, according to the information of the local superintendent, the wilt had broken out naturally. The peculiar conditions which we found here require a detailed description of the locality and of the manner in which the disease operated. The largest part of the forest, about 20 acres, is situated upon the ridge of a hill. On the east and west the hill slopes to wet meadows. On the north and south the hill gently passes over into level country, and it is bordered here by broad roads. The principal trees on the ridge of the hill are high pines about sixty to eighty years of age; brush is almost absent. The slopes are covered in large part with young oaks, which are much mixed with brush of different kinds. Now, while the forest of the whole ridge, including the northern and southern slopes, suffered considerably from injuries by gypsy moth caterpillars during the summer of 1910, the eastern and western slopes were exempt from this damage. Soon after the caterpillars had passed the third molt Flacherie made its appearance among those feeding on the pines upon the ridge of the hill. The disease developed here so rapidly that probably all caterpillars were killed, for we were unable, even by careful search in these 20 acres, on Sept. 7, 1910, to find a single fresh cluster. The statement, therefore, seems justified that all caterpillars, at least all the females (100 per cent.), were here killed by the wilt. This very high number, however, was restricted to the forest upon the ridge of the hill. On the first trees of the northern and southern slopes fresh egg clusters were found, and the number of these increased as we went toward the plain. But the inspection of such dead caterpillars as were observed showed that the wilt had also operated in the woods of these slopes. The local superintendent looked here for Flacherie, but it did not appear till the caterpillars were in their last stage. The reason for this behavior of the wilt might be that the ridge of the hill, with its high trees, was much exposed to the effect of the wind, and after Flacherie had once developed it could be spread very rapidly along the ridge. On the northern

¹ Similar observations, where eggs have not hatched, were made elsewhere by different persons connected with the moth work, but no definite observations, as at Concord, were reported.

and southern slopes, however, the wind could not strike so hard, and the spreading of *Flacherie* toward the plain, therefore, took place comparatively slowly. Upon the eastern and western slopes, on account of the lack of caterpillars, the conditions necessary for developing the wilt were not present.

A map of the place, sketched by Mr. Richardson (Fig. 2), which may aid in understanding the description, is given herewith.

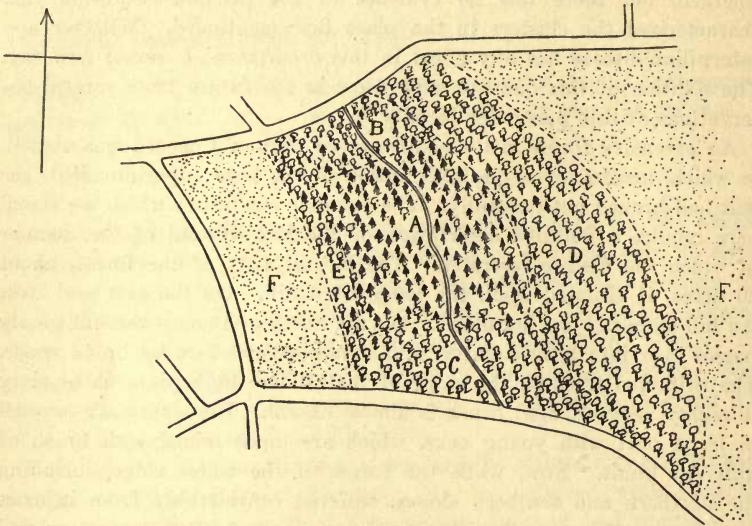


Fig. 2.—Experiment, Concord, Mass. A. Summit of hill, now cleared. B. Northern slope, infested. C. Southern slope, infested. D. Eastern slope, not eaten. E. Western slope, not eaten. F. Meadows.

Five clusters were examined for comparison from the localities in which *Flacherie* developed naturally. These were collected on a walk through the forest district at the southern end of the hill, and from different trees taken at random. The result was:—

Cluster 1.

Unfertilized eggs, . . .	4	} = 12.59 per cent., or about 12.5 per cent.
Eggs with dead embryos, . . .	16	
Eggs apparently alive, . . .	139	
Total, . . .	159 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 5.30 per cent., or about 5 per cent.
Eggs with dead embryos, . . .	6	
Eggs apparently alive, . . .	143	
Total, . . .	151 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	} = 2.14 per cent., or about 2 per cent.
Eggs with dead embryos, . .	4	
Eggs apparently alive, . . .	229	
Total, ...	234 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 3.17 per cent., or about 3 per cent.
Eggs with dead embryos, . .	3	
Eggs apparently alive, . . .	122	
Total, ...	126 eggs.	

Cluster 5.

Unfertilized eggs, . . .	6	} = 12.93 per cent., or about 13 per cent.
Eggs with dead embryos, . .	32	
Eggs apparently alive, . . .	256	
Total, ...	294 eggs.	

Averaging these 5 clusters we get this result:—

Dead eggs, ...	15	= 7.77 per cent., or about 7.5 per cent.
Eggs apparently alive, . . .	178	= 92.23 per cent., or about 92.5 per cent.
Total, ...	193 eggs.	

We notice also that the egg clusters from this place, where the wilt developed naturally, are considerably less than the normal size, about $2\frac{1}{2}$ clusters being equal to 1 normal cluster. This, and the fact that only 7.5 per cent. of the eggs would fail to hatch, while in the experiment 17 per cent. were dead, is probably due to the fact that upon this southern slope Flacherie appeared late and spread but slowly.

North Carver, Mass.

Division Agent, JOHN A. FARLEY; Local Superintendent, HERBERT F. ATWOOD.

This locality was visited on May 9, 1910, with the inspector of the southern districts of the State of Massachusetts, Mr. Norman Souther of Bridgewater, to find suitable places for the intended experiments. The gypsy moth does not occur here in such enormous numbers as in the northern parts of the State, but I wished to have some experiments at places where the gypsy moth has but recently gained a foothold.

An isolated wood of about 2 acres, situated somewhat southwest from Makepeace's cranberry bog, was found to be a suitable place. It consists of pines about forty years old and of oaks about twenty to twenty-five years of age, with considerable brush.

The gypsy moth was discovered here for the first time during the winter of 1909-10, by finding egg clusters. Several of these clusters, unfortunately, had been already killed with creosote before my first visit, but there were present, according to Mr. Souther's and my estimation, about 25 clusters. Whether there was any disease among the caterpillars of the previous year could not be ascertained, but it is highly improbable, considering the youth of the colony and the large size of the clusters.

On June 14, 1910, the local superintendent sent me word that wilt had made its appearance among the caterpillars which he had collected and fed according to instructions. I therefore went to North Carver on June 16, and found that in Mr. Atwood's colony about 3 per cent. of the caterpillars had already died of Flacherie. Most of those still living were very sick. He therefore had developed the wilt artificially after a feeding of about fourteen days.

This same day, with the assistance of the local superintendent, a part of the breeding material was exposed on the western side of the selected place. The bag containing the material was fastened about 8 feet from the ground, between young oak trees. Most of the caterpillars of this locality had just passed the third molt.

On Oct. 7, 1910, an extended search was made by the local superintendent and myself, but only 4 fresh clusters could be found. The microscopic examination of these 4 clusters resulted as follows:—

Cluster 1.

Unfertilized eggs, . . .	5	} = 6.03 per cent., or about 6 per cent.
Eggs with dead embryos, . .	21	
Eggs apparently alive, . .	405	
Total, . . .	431 eggs.	

Cluster 2.

Unfertilized eggs, . . .	3	} = 5.38 per cent., or about 5.5 per cent.
Eggs with dead embryos, . .	18	
Eggs apparently alive, . .	375	
Total, . . .	396 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	} = 4.65 per cent., or about 4.5 per cent.
Eggs with dead embryos, . .	8	
Eggs apparently alive, . .	205	
Total, . . .	215 eggs.	

Cluster 4.

Unfertilized eggs, . . .	3	} = 13.38 per cent., or about 13.5 per cent.
Eggs with dead embryos, . .	18	
Eggs apparently alive, . . .	136	
Total, ...	157 eggs.	

Averaging these 4 clusters we get:—

Dead eggs, ...	20	= 6.67 per cent., or about 6.5 per cent.
Eggs apparently alive, . . .	280	= 93.33 per cent., or about 93.5 per cent.
Total, ...	300 eggs.	

Since, as we have seen, a normal cluster contains on the average 433 eggs with apparently living embryos, the living eggs of these 4 clusters, after the wilt did its work, amount to about 64.5 per cent. The egg clusters which were present in the spring of 1910 were estimated at about 25, while only 4 fresh clusters were found in the autumn of 1910. The total number of all apparently living eggs was decreased in this locality to about 13 per cent., as compared with the number present in the spring of 1910.

Another place for experiments, very similar to the last one, was selected in North Carver. This is a forest district of 3 acres, and is situated east of the cemetery on Wenham Street. The timber and brush here are the same as in the other locality, and the egg clusters of the gypsy moth were also first discovered here during the winter of 1909-10. Unfortunately, several clusters were killed with creosote before my first visit. The clusters still present were estimated by Mr. Souther and myself at about 600. On account of the young age of the colony and the considerable size of the clusters probably no disease had appeared among the caterpillars of the preceding year.

The remaining part of the wilt material was planted among the caterpillars of this locality on the same day and in the same manner as in the first colony. Here, also, most of the caterpillars at this time had just undergone the third molt.

The estimate of the fresh clusters, which was made by the local superintendent and myself Oct. 7, 1910, was about 400, from which the first 5 found were used for microscopical examinations. The result is as follows:—

Cluster 1.

Unfertilized eggs, ...	-	} = 4.11 per cent., or about 4 per cent.
Eggs with dead embryos, . . .	12	
Eggs apparently alive, ...	280	
Total, ...	292 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 17.17 per cent., or about 17 per cent.
Eggs with dead embryos, . .	38	
Eggs apparently alive, . .	193	
Total, . . .	233 eggs.	

Cluster 3.

Unfertilized eggs, . . .	-	} = 7.38 per cent., or about 7 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . .	113	
Total, . . .	122 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 4.89 per cent., or about 5 per cent.
Eggs with dead embryos, . .	14	
Eggs apparently alive, . .	292	
Total, . . .	307 eggs.	

Cluster 5.

Unfertilized eggs, . . .	2	} = 2.95 per cent., or about 3 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . .	362	
Total, . . .	373 eggs.	

Averaging these 5 clusters we get:—

Dead eggs, . . .	17	= 6.42 per cent., or about 6.5 per cent.
Eggs apparently alive, . .	248	= 93.58 per cent., or about 93.5 per cent.
Total, . . .	265 eggs.	

Since this place, after infection with *Flacherie*, contains on the average only 248 eggs with apparently living embryos per cluster, almost 2 clusters of this locality are necessary to equal a normal cluster. The number of the fresh clusters, estimated at about 400, thus has to be reduced to about 250. The number of apparently living eggs in this locality therefore decreased, after the wilt had operated, to about 42 per cent.¹

¹ This forest was cut down by the owner in the beginning of the winter of 1910-11, and all egg clusters which the forest contained were collected by the local superintendent; 444 clusters were found. Our estimate of the clusters in the autumn, which was 400, therefore was nearly correct. The number of apparently living eggs which remained after *Flacherie* did its work has to be increased 3 per cent., that is to say, to 45 per cent.

Boxford, Mass.

Division Agent, FRANCIS C. WORTHEN; Assistant Local Superintendent, HARRY L. COLE.

Two places were selected in the West Boxford district for the intended experiments. The locality which we shall consider first is situated opposite the almshouse, near the Almshouse Road, and is only about a quarter of an acre in size. This small isolated wood is composed of oaks almost fifty to sixty years of age, and there is no brush. The gypsy moth caterpillars were numerous here in the summer of 1909. No disease had been noticed among them, according to Mr. Worthen and Mr. Cole, nor have any artificial means of destroying the gypsy moth been undertaken here. Mr. Worthen and I estimated the number of egg clusters at the time of my first visit, on May 6, 1910, at about 200.

Mr. Cole was intrusted with raising the caterpillars for the Boxford experiments. Having received no notice of the wilt making its appearance in the brood, on the 14th of June, 1910, I went to Boxford to inspect the material. It was found that Mr. Cole had reared the caterpillars in a very cold cellar, where they were eating but little and were retarded considerably in their development. He was instructed to place the caterpillars immediately in a warmer place in the open air. On June 19, 1910, a letter from him announced that *Flacherie* had broken out in his brood. On June 21 I went to Boxford to confirm his statement. About 5 per cent. of the caterpillars of this brood had already died of *Flacherie*, and most of the individuals still living showed all the signs of the disease.

One part of this brood was exposed, with the assistance of Mr. Cole, on the same day in the western part of the selected locality. The bag containing the material was fastened between twigs of oak trees, about 6 feet from the ground. Most of the caterpillars of this locality were at this time about ready for the fourth molt.

The fresh clusters at this place were estimated, on Aug. 26, 1910, by the division agent and myself, to be about 60. The first 5 clusters which were found were collected and examined. The examination resulted as follows:—

Cluster 1.

Unfertilized eggs, ...	-	} = 4.92 per cent., or about 5 per cent.
Eggs with dead embryos, ...	6	
Eggs apparently alive, ...	116	= 95.08 per cent., or about 95 per cent.
Total, ...	122 eggs.	

Cluster 2.

Unfertilized eggs, . . .	1	} = 10.16 per cent., or about 10 per cent.
Eggs with dead embryos, . .	12	
Eggs apparently alive, . .	115	= 89.84 per cent., or about 90 per cent.
Total, ...	128	eggs.

Cluster 3.

Unfertilized eggs, . . .	3	} = 7.14 per cent., or about 7 per cent.
Eggs with dead embryos, . .	4	
Eggs apparently alive, . .	91	= 92.86 per cent., or about 93 per cent.
Total, ...	98	eggs.

Cluster 4.

Unfertilized eggs, . . .	8	} = 28.24 per cent., or about 28 per cent.
Eggs with dead embryos, . .	16	
Eggs apparently alive, . .	61	= 71.76 per cent., or about 72 per cent.
Total, ...	85	eggs.

Cluster 5.

Unfertilized eggs, . . .	-	} = 2.96 per cent., or about 3 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . .	164	= 97.04 per cent., or about 97 per cent.
Total, ...	169	eggs.

The average of these 5 clusters gives the following result:—

Dead eggs, ...	11	= 9.17 per cent., or about 9 per cent.
Eggs apparently alive, . .	109	= 90.83 per cent., or about 91 per cent.
Total, ...	120	eggs.

Since this place, weakened by the wilt, contained only 109 eggs with apparently living embryos to the cluster, almost 4 clusters were necessary to equal the size of a normal cluster. The number of fresh egg clusters, which were estimated at 60, thus must be reduced to about 20 clusters. The number of apparently living eggs was therefore decreased, as the result of *Flacherie*, to about 10 per cent.

The second place which was selected in West Boxford for experiments with the disease consists of an isolated wood of about half an acre. Most of the trees are oaks about thirty years of age, mixed with underbrush. This locality is situated on Highland Street, between two apple orchards. In the summer of 1909 the gypsy moth caterpillars were relatively more numerous than at the first place. No dis-

ease was noticed among them by Messrs. Worthen and Cole, but it is nevertheless possible that the wilt might have made its appearance. No artificial means for destroying the gypsy moth had been undertaken here. The number of egg clusters present at the time of my first visit in the spring of 1910 was estimated by Mr. Worthen and myself at about 550.

Flacherie, which had been developed artificially by Mr. Cole, was planted in this locality June 21, 1910, in the same manner as in the place first described. The caterpillars were about ready for the fourth molt, as in the first experiment. With the assistance of the division agent the fresh clusters at this locality were estimated on Aug. 26, 1910, to be about 80. The microscopical examination of the first 5 clusters found shows:—

Cluster 1.

Unfertilized eggs, . . .	1	} = 6.67 per cent., or about 6.5 per cent.
Eggs with dead embryos, . .	10	
Eggs apparently alive, . .	154	
Total, ...	165 eggs.	

Cluster 2.

Unfertilized eggs, . . .	1	} = 6.25 per cent., or about 6 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . .	90	
Total, ...	96 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	} = 7.09 per cent., or about 7 per cent.
Eggs with dead embryos, . .	7	
Eggs apparently alive, . .	118	
Total, ...	127 eggs.	

Cluster 4.

Unfertilized eggs, . . .	3	} = 9.68 per cent., or about 9.5 per cent.
Eggs with dead embryos, . .	12	
Eggs apparently alive, . .	140	
Total, ...	155 eggs.	

Cluster 5.

This cluster proved to be entirely without eggs, and it consisted only of a mass of wool of about 1 square centimeter in size. The female moth, which deposited this cluster, seems to have been absolutely sterile. It started mechanically, it is true, to lay eggs, but of course it could deposit nothing except the hairs from its abdomen.

The average of these clusters gives the following result:—

Dead eggs, ...	8	= 7.34 per cent., or about 7 per cent.
Eggs apparently alive, ...	101	= 92.66 per cent., or about 93 per cent.
Total, ...	109 eggs.	

Since this locality, which had been infected with the wilt, showed only 101 eggs with apparently living embryos on the average per cluster, about 4 clusters would be equal to a normal one. The fresh egg clusters, which were estimated at about 80, thus have to be reduced to about 20. The number of apparently living eggs in this infested locality has thus decreased to about 4 per cent.

A third locality in which the wilt appeared naturally was somewhat closely inspected. A small isolated wood of about 3,000 square feet is situated on Main Street, about 500 yards south of Wood's Corner. The trees consist of oaks a hundred years or more of age, and the place is free from underbrush. The gypsy moth caterpillars were very numerous here in the summer of 1909, but no definite statement can be made as to whether or not there was disease among them. If the disease was present, it was doing little harm, as otherwise dead caterpillars in large numbers would have been noticed, without doubt, by the division agent or the local superintendent. Mr. Worthen estimated the number of clusters present in the spring of 1910 at about 400. No artificial means for destroying the gypsy moth were undertaken. Measured in a straight line this place is at least 1 mile from the nearest of the two localities previously mentioned. Flacherie was noticed here at a time when most caterpillars were in the fourth molt. Here, too, the disease worked considerably among the caterpillars. It was hard to find even 50 clusters when Mr. Worthen and I estimated the freshly laid ones, on Aug. 26, 1910. For comparison the first 5 clusters found were collected and examined. They gave the following results:—

Cluster 1.

Unfertilized eggs, ...	—	} = 11.27 per cent., or about 11 per cent.
Eggs with dead embryos, ...	8	
Eggs apparently alive, ...	63	= 88.73 per cent., or about 89 per cent.
Total, ...	71 eggs.	

Cluster 2.

Unfertilized eggs, ...	1	} = 10.28 per cent., or about 10 per cent.
Eggs with dead embryos, ...	10	
Eggs apparently alive, ...	96	= 89.72 per cent., or about 90 per cent.
Total, ...	107 eggs.	

Cluster 3.

Unfertilized eggs, ...	2	} = 6.94 per cent., or about 7 per cent.
Eggs with dead embryos, ...	8	
Eggs apparently alive, ...	134	= 93.06 per cent., or about 93 per cent.

Total, ... 144 eggs.

Cluster 4.

Unfertilized eggs, ...	—	} = 4.26 per cent., or about 4 per cent.
Eggs with dead embryos, ...	4	
Eggs apparently alive, ...	90	= 95.74 per cent., or about 96 per cent.

Total, ... 94 eggs.

Cluster 5.

Unfertilized eggs, ...	2	} = 8.59 per cent., or about 8.5 per cent.
Eggs with dead embryos, ...	12	
Eggs apparently alive, ...	149	= 91.41 per cent., or about 91.5 per cent.

Total, ... 163 eggs.

The average of these 5 clusters gives the following result:—

Dead eggs, ...	9	= 7.08 per cent., or about 7 per cent.
Eggs apparently alive, ...	106	= 92.92 per cent., or about 93 per cent.

Total, ... 115 eggs.

Thus in this locality, also, in which the wilt appeared naturally, the egg clusters were far below the normal size. Examination showed that about 4 of these clusters would be necessary to equal a normal one in size. The estimated sum of 50 clusters, therefore, must be reduced to about 14. Hence, the apparently living eggs which remained amount to about 4 per cent.

Finally, a forest of about 30 acres was inspected. This is situated at an angle of 45°, and half a mile distant from the two first localities. In this forest, which consists mainly of large pines and oaks, the gypsy moth caterpillars had been present in considerable numbers during the summer of 1909, and were still more numerous during the first part of the summer of 1910. The owners of this place intended, according to the division agent, to cut down the forest, thus preventing a total stripping and decrease of the value of the wood. A powerful ally came to the support of the owners during the latter part of the summer of 1910, in the guise of Flacherie, which cleared up the caterpillars in a manner that left nothing to be desired. It cannot be determined whether the disease appeared naturally or was spread to this

forest from the two localities in which the experiments were performed. However this may be, the wilt had acted at any rate in such a virulent manner that in all these 30 acres of forest not a single fresh egg cluster could be found, notwithstanding the most painstaking search on the part of Mr. Worthen and myself.

Mr. Worthen also undertook, on his own behalf, the breeding of several hundred caterpillars, feeding them according to my instructions. The disease could be noticed in this brood as early as June 14, 1910. Most of these caterpillars had just passed the third molt. Three days later he exposed all the material among the caterpillars of a forest near his home. Soon he observed the "dying off" of the caterpillars which were there present. The number of the dead ones grew astonishingly, but the final result cannot be stated, since, unfortunately, the trees were later sprayed with arsenate of lead.

West Bedford, Mass.

The division agent and the local superintendent in this locality were not requested to perform the experiments. My friend, Mr. L. W. Swett, the well-known specialist in Geometridæ, asked me in the spring of 1910 to undertake an experiment with the wilt upon his estate on Davis Street, northeast of the railroad station, in West Bedford. We inspected the place for this purpose on May 29, and the locality appeared to be a very suitable one for the work. It consists of two isolated strips of wood, which meet at a right angle. One strip comprises oaks about fifty years of age, mixed with some brush; while the other consists of dense birch brush about six years old. The whole locality comprises about three-quarters of an acre. The gypsy moth was first discovered here in 1908, and the place since that time has been under continuous observation by Mr. Swett. He assured me that there were positively no signs of a disease among the caterpillars. During the summer of 1909 the caterpillars were quite numerous. Part of the egg clusters, which were laid in the autumn of 1909, were killed with creosote, but there were still present, according to Mr. Swett's and my estimation at the time of my first visit, about 400 clusters on the oaks and about 100 clusters on the birches.

The caterpillars for this experiment were raised by the author at Forest Hills. They began to die from *Flacherie* after a continuous feeding of fourteen days, and just as they had passed the third molt. This material was planted, June 22, 1910, in the birch brush, and the bag was fastened about 6 feet from the ground. Most of the caterpillars of this locality were at that time half way between the third and fourth molt. The place was visited again on July 18, 1910, to determine the progress of the disease. Mr. Swett and I found that the caterpillars were dying in considerable numbers, and the percentage of dead individuals was greatest on the shortest brush, and decreased

gradually the higher the vegetation grew. For instance, all the caterpillars which had been feeding on the small willow brushes were already dead. This brush, hardly 3 feet high, occurs here and there in front of the two rows of woods. The dead caterpillars were readily seen, as they were hanging all over the brush. Many of the caterpillars on the birches were dying, but a considerable number of living individuals was still present. In the colony of the high oaks, however, the wilt had

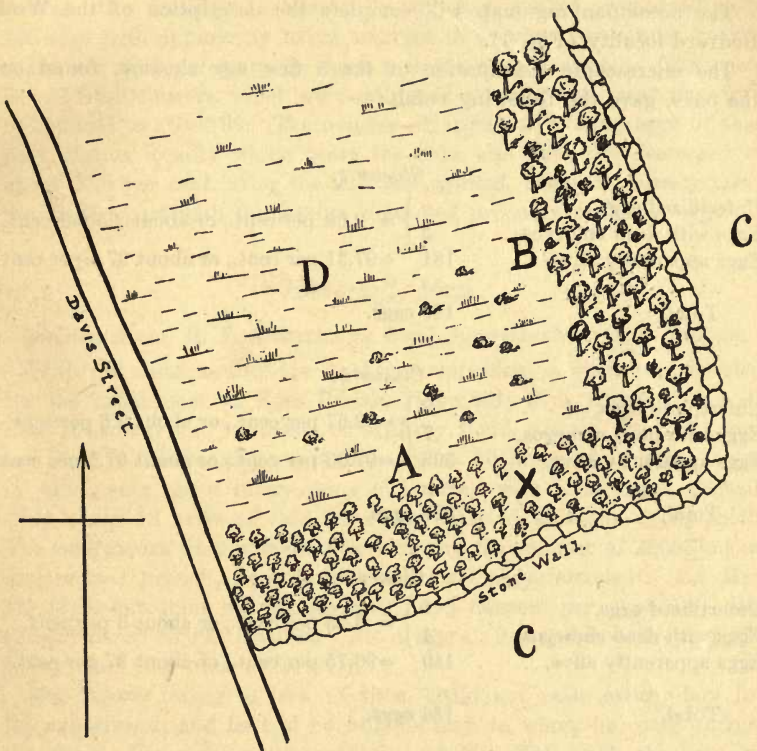


Fig. 3.—Experiment, West Bedford, Mass. A. Dense birches. X. Exposure of disease. B. Oaks and underwood. C. Field. D. Marshy meadow with a few scattered willows.

not spread so much, although dead individuals were found in considerable numbers.

On Sept. 23, 1910, the freshly laid egg clusters were estimated. We made the interesting discovery that there existed no fresh clusters in the row overgrown with birch. Thus, all the caterpillars, at least the females, had been killed by *Flacherie*. To be certain of this fact the crevices of the bordering stone wall were carefully examined, since the gypsy moth female selects with preference such hidden places for oviposition. But no fresh clusters could be found here. The other row with the high oaks, however, proved to have a relatively large number

of fresh clusters, which were estimated at about 150. Mr. Swett later made an examination and confirmed these facts. There is no sufficient explanation so far for the peculiar behavior of the wilt in this locality. Apparently the wind here played a special rôle. The difference in the vegetation may also have had some influence. Does the eating of birch foliage hasten the production of the disposition to Flacherie among the caterpillars?

The accompanying map will complete the description of the West Bedford locality (Fig. 3).

The microscopic examination of the 5 first egg clusters, found on the oaks, gave the following result:—

Cluster 1.

Unfertilized eggs, . . .	—	} = 2.69 per cent., or about 2.5 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . .	181	
Total, ...	186 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 2.67 per cent., or about 2.5 per cent.
Eggs with dead embryos, . .	7	
Eggs apparently alive, . .	328	
Total, ...	337 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	} = 3.25 per cent., or about 3 per cent.
Eggs with dead embryos, . .	4	
Eggs apparently alive, . .	149	
Total, ...	154 eggs.	

Cluster 4.

Unfertilized eggs, . . .	12	} = 20.65 per cent., or about 20.5 per cent.
Eggs with dead embryos, . .	58	
Eggs apparently alive, . .	269	
Total, ...	339 eggs.	

Cluster 5.

Unfertilized eggs, . . .	1	} = 3.19 per cent., or about 3 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . .	303	
Total, ...	313 eggs.	

The average of these 5 clusters gives the following result:—

Dead eggs, ...	20	= 7.52 per cent., or about 7.5 per cent.
Eggs apparently alive, ...	246	=92.48 per cent., or about 92.5 per cent.
Total, ...	266	eggs.

Since this locality, in which the wilt has worked, contained only 246 eggs with apparently living embryos in average per cluster, nearly 2 clusters were necessary to equal a single normal cluster. The number of fresh clusters, which were estimated at about 150, must therefore be reduced to about 90. The number of apparently living eggs of that part of this locality which bears the oaks was therefore decreased to about 22.5 per cent. after the wilt had worked, while, as already mentioned, the part with the birches contained probably no living eggs.

Haverhill, Mass.

Division Agent, H. F. ARMSTRONG; Local Superintendent, G. F. MOORE.

With the assistance of the local superintendent a place was selected for the experiment in East Parish, Haverhill; it is situated west of East Broadway and northeast of Millway Pond, and on the Old Country Road. This locality represents almost 50 acres of isolated forest, in which oaks about thirty years old, mixed with underbrush, prevail. Only about 12 acres of this forest are infested with the gypsy moth. The caterpillars were numerous here during the summer of 1909, but no disease was present, according to the local superintendent. On May 18, 1910, our joint estimation gave 1,000 clusters per acre, *i.e.*, altogether about 12,000 clusters. No artificial means of destroying the gypsy moth had been undertaken.

Mr. Moore, owing to lack of time, could not raise caterpillars for the experiment, and he had no reliable man to whom he could entrust the work. Upon the recommendation of Mr. Fitzgerald, the field inspector of the northern divisions, the brother of the local superintendent of Methuen, Mass., Mr. Wagland, was intrusted with the raising of the caterpillars. As no communication was received from Mr. Walter Wagland by June 21, 1910, that his caterpillars showed signs of *Flacherie*, I went on this day to Methuen, to convince myself of the condition of the insects. The local superintendent, A. H. Wagland, Mr. Walter Wagland's brother, was with me, and we found that all the caterpillars were sick and that several had already died. The reason why I had received no word from Mr. Walter Wagland was that he did not recognize the disease. The planting of the material in the selected place in Haverhill was accomplished the next day. All the material was exposed in a pasteboard box in the western part of the forest, about 6 feet from the ground and between limbs of oak trees.

Most of the caterpillars of this locality were at this time about half way between the third and fourth molts.

The place was visited again Aug. 30, 1910, with the local superintendent of Haverhill, to see how the wilt had operated, and how many fresh egg clusters were present. First it was noticed that the infested portion of the forest was not uniformly infected with Flacherie. While the periphery of the infested area (about 8 to 9 acres) showed a very considerable decrease of the egg clusters in comparison with those of the spring of 1910, the real center of the colony, which covered 3 to 4 acres, had been more resistant to the disease, although here also the number of the fresh clusters had decreased considerably in comparison with the clusters of the previous year. Altogether the number of fresh clusters of the whole colony was estimated by us to be about 3,500. The 5 clusters which served for examination proved to be as follows:—

Cluster 1.

Unfertilized eggs, . . .	8	} = 28.57 per cent., or about 28.5 per cent.
Eggs with dead embryos, . .	28	
Eggs apparently alive, . . .	90	
Total, ...	126 eggs.	

Cluster 2.

Unfertilized eggs, . . .	-	} = 3.31 per cent., or about 3 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . . .	146	
Total, ...	151 eggs.	

Cluster 3.

Unfertilized eggs, . . .	4	} = 5.63 per cent., or about 5.5 per cent.
Eggs with dead embryos, . .	13	
Eggs apparently alive, . . .	285	
Total, ...	302 eggs.	

Cluster 4.

Unfertilized eggs, . . .	7	} = 12.36 per cent., or about 12 per cent.
Eggs with dead embryos, . .	25	
Eggs apparently alive, . . .	227	
Total, ...	259 eggs.	

Cluster 5.

Unfertilized eggs, . . .	-	} = 1.95 per cent., or about 2 per cent.
Eggs with dead embryos, . .	6	
Eggs apparently alive, . . .	302	
Total, ...	308 eggs.	

The average of these 5 clusters gives the following result:—

Dead eggs, ...	19	= 8.30 per cent., or about 8 per cent.
Eggs apparently alive, ...	210	= 91.70 per cent., or about 92 per cent.
Total, ...	229	eggs.

Since a normal cluster contains, on the average, 433 eggs with apparently living embryos, and this locality in which Flacherie had prevailed contained only 210 eggs with apparently living embryos on the average per cluster, 2 clusters were necessary to equal a normal one. The number of fresh clusters, which were estimated to be about 3,500, must therefore be reduced to about 1,750. The number of apparently living eggs had decreased in this locality, after the wilt had operated, to about 14.5 per cent.

Marshfield, Mass.

Division Agent, JOHN A. FARLEY; Local Superintendent, P. R. LIVERMORE.

I did not visit this locality, but the experiment was undertaken by the local superintendent with the assistance of Mr. Joseph Shermann of Marshfield, who raised the caterpillars according to my instructions. On visiting Marshfield on June 24, 1910, it was found that Mr. Shermann's caterpillars, most of which were ready to undergo the fourth molt, were sick with Flacherie. He was instructed to expose the material, with the assistance of the local superintendent, in a forest infested with the gypsy moth. This was done on June 26, 1910, in a forest of 10 acres. On Oct. 25, 1910, the local superintendent sent, upon my request, a number of fresh egg clusters from the locality where the disease had been planted, and he remarked that the number of egg clusters were considerably decreased in comparison with those present in the spring of 1910. Unfortunately, further detailed communications regarding this locality were not received. The first 5 clusters, which were taken from the top of the shipment, were examined microscopically. The result was as follows:—

Cluster 1.

Unfertilized eggs, ...	1	} = 4.26 per cent., or about 4 per cent.
Eggs with dead embryos, ...	10	
Eggs apparently alive, ...	247	
Total, ...	258 eggs.	

Cluster 2.

Unfertilized eggs, ...	8	} = 13.47 per cent., or about 13.5 per cent.
Eggs with dead embryos, ...	65	
Eggs apparently alive, ...	469	
Total, ...	542 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	} = 10.59 per cent., or about 10.5 per cent.
Eggs with dead embryos, . .	41	
Eggs apparently alive, . .	363	
Total, ...	406 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 5.28 per cent., or about 5 per cent.
Eggs with dead embryos, . .	14	
Eggs apparently alive, . .	269	
Total, ...	284 eggs.	

Cluster 5.

Unfertilized eggs, . . .	4	} = 6.64 per cent., or about 6.5 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . .	181	
Total, ...	194 eggs.	

The average of these 5 clusters gives the following result:—

Dead eggs, ...	31	= 9.20 per cent., or about 9 per cent.
Eggs apparently alive, . .	306	= 90.80 per cent., or about 91 per cent.
Total, ...	337 eggs.	

After the wilt had operated in this locality the size of the egg clusters was not up to the average size of the normal cluster, and the percentage of dead eggs was very high.

Kingston, Mass.

Division Agent, JOHN A. FARLEY; Local Superintendent, C. C. FAUNCE.

With the help of the field inspector, Mr. Norman Souther of Bridgewater, two places were selected for the intended experiments. The locality which we will first consider is an isolated part of the so-called "Rocky Nook," and is situated about 1 mile east of the Kingston-Plymouth car line. This place is about a quarter of an acre in size and mainly overgrown with oaks about twenty-five years of age. The gypsy moths were discovered here in the autumn of 1909 by finding egg clusters. The youth of the colony made it seem improbable that there was any disease among the caterpillars of 1909, and, moreover, the egg clusters had a considerable size. Several of the clusters found had been killed with creosote, but there were still left about 60 clusters, according to Mr. Souther's and my estimate.

The local superintendent was intrusted by Mr. Souther with the breeding of caterpillars. On June 24, 1910, I found the wilt in this brood. The same day, with the assistance of the local superintendent, one part of the material was exposed in the locality mentioned. This brood was thoroughly sick, but the "dying off" of the caterpillars had not begun. The bag containing the material was fastened between twigs about 7 feet from the ground. The caterpillars in this locality were at this time half way between the third and fourth molt.¹

On Oct. 25, 1910, the fresh egg clusters of this locality were estimated by the local superintendent and myself. We found that the place contained almost the same numbers of clusters as in the spring of 1910, with the difference, however, that many clusters had the hairy covering only in part. Several clusters completely lacked this covering. It seems that the disease spread very slowly, and that it did not kill many caterpillars but had merely given them a mild form of the disease, which manifested itself later in the manner mentioned, when the females laid their eggs. The 5 clusters which were first found were examined, like those of other localities. The examination gave the following interesting results:—

Cluster 1.

Unfertilized eggs, . . .	2	} = 3.97 per cent., or about 4 per cent.
Eggs with dead embryos, . .	13	
Eggs apparently alive, . . .	363	
Total, ...	378 eggs.	

Cluster 2.

Unfertilized eggs, . . .	6	} = 18.85 per cent., or about 19 per cent.
Eggs with dead embryos, . .	92	
Eggs apparently alive, . . .	422	
Total, ...	520 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	} = 13.48 per cent., or about 13.5 per cent.
Eggs with dead embryos, . .	58	
Eggs apparently alive, . . .	385	
Total, ...	445 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 20.98 per cent., or about 21 per cent.
Eggs with dead embryos, . .	123	
Eggs apparently alive, . . .	467	
Total, ...	591 eggs.	

¹ This experiment was intentionally undertaken with sick caterpillars only, and no dead ones, in order to see what effect the exposure of only sick individuals might have upon the healthy caterpillars in the field.

Cluster 5.

Unfertilized eggs, ...	-	}	= 6.06 per cent., or about 6 per cent.
Eggs with dead embryos, ...	2		
Eggs apparently alive, ...	31		= 93.94 per cent., or about 94 per cent.
Total, ...	33	eggs.	

The average of these 5 clusters gives the following result:—

Dead eggs, ...	60	= 15.23 per cent., or about 15 per cent.
Eggs apparently alive, ...	334	= 84.77 per cent., or about 85 per cent.
Total, ...	394	eggs.

Since this place, in which Flacherie had operated, contained on the average only 334 eggs with apparently living embryos per cluster, the size of these clusters was about one-quarter less than normal. The fresh clusters, which were estimated to be about 60, *i.e.*, the same number which was found in the spring, thus must be reduced to about 45. The number of apparently living eggs of this locality therefore was decreased, after the wilt had worked, to about 77 per cent.

This experiment also shows that the exposure of sick instead of dead caterpillars contributes to the spread of the wilt. As in such cases, however, the disease spreads slowly, the caterpillars, it is true, will not be killed in large numbers, but they will be infected more or less lightly. The result is that a high percentage of the eggs deposited by the females will fail to hatch.

The second place which was selected in Kingston for an experiment is situated on the eastern side of Jones River, opposite the poor farm. This is an isolated wood of about one-eighth of an acre in size, which contains several large oaks and underbrush. The gypsy moth was discovered here also by the finding of egg clusters first in the autumn of 1909. It cannot be stated whether disease was present among the caterpillars of the summer of 1909, but this seems improbable, owing to the youth of the colony. Several of the clusters were killed with creosote, but there were still left, according to Mr. Souther's estimate, about 50 clusters.

The planting of the sick material was accomplished on the same day and in the same manner as in the first locality. Estimating the fresh clusters on Oct. 25, 1910, unfortunately I found that most of these fresh clusters (about 25) had been already killed with creosote by the men working under the local superintendent. Even with the assistance of the local superintendent, only 2 untouched egg clusters could be found. Only 1 of these could be collected, since the second was out of reach. Although, therefore, we are unable to draw any

complete and final conclusions in regard to the work of the wilt in this locality, nevertheless the result of the examination of the single cluster which could be secured may be given:—

Unfertilized eggs, ...	1	} = 3.52 per cent., or about 3.5 per cent.
Eggs with dead embryos, ...	12	
Eggs apparently alive, ...	356	
Total, ...	369 eggs.	

All we can say concerning this locality is that through the operation of Flaeherie, which was introduced by sick material only, the number of fresh clusters seems to have been reduced in comparison with that of the previous year.

Brockton, Mass.

Division Agent, L. W. HODGKINS; Local Superintendent, E. MOLTAN.

The place which, with the assistance of the inspector, Mr. Norman Souther of Bridgewater, was selected for an experiment, is situated near Oak Street, northwest of Brockton Center and east of the Dutchland Farm. The place, of about half an acre, consists of a growth of oaks about forty to fifty years of age; no brush is present. The caterpillars of the gypsy moth were abundant here in the summer of 1909, but no disease was noticed among them. Several of the clusters were killed with creosote during the winter of 1909-10. The clusters which were left were estimated by Mr. Souther and myself to be about 40.

The raising of caterpillars for the intended experiment Mr. Souther intrusted to Mr. Rudolph Marshall, 218 Battle Street, Brockton. On June 24, 1910, the brood was inspected. Several caterpillars had already died from the wilt and the others were found to be sick. This same day the whole material was exposed in the selected place. The bag was fastened between oak limbs, about 8 feet from the ground. Most of the caterpillars of this locality were at this time about half way between the third and fourth molt.

This place was visited again on Oct. 7, 1910, with Mr. Souther, to determine the number of fresh clusters. But in spite of the most strenuous search there were found but 4 clusters; these were collected for examination. They resulted as follows:—

<i>Cluster 1.</i>		
Unfertilized eggs, ...	2	} = 2.99 per cent., or about 3 per cent.
Eggs with dead embryos, ...	10	
Eggs apparently alive, ...	389	
Total, ...	401 eggs.	

Cluster 2.

Unfertilized eggs, . . .	13	} = 11.71 per cent., or about 11.5 per cent.
Eggs with dead embryos, . .	22	
Eggs apparently alive, . .	264	
Total, ...	299 eggs.	

Cluster 3.

Unfertilized eggs, . . .	3	} = 5.47 per cent., or about 5.5 per cent.
Eggs with dead embryos, . .	14	
Eggs apparently alive, . .	294	
Total, ...	311 eggs.	

Cluster 4.

Unfertilized eggs, . . .	2	} = 4.81 per cent., or about 5 per cent.
Eggs with dead embryos, . .	18	
Eggs apparently alive, . .	396	
Total, ...	416 eggs.	

The average of these 4 clusters gives the following result:—

Dead eggs, ...	21	= 5.88 per cent., or about 6 per cent.
Eggs apparently alive, . .	336	= 94.12 per cent., or about 94 per cent.
Total, ...	357 eggs.	

Since this place, in which the wilt had operated, contained only 336 eggs with apparently living embryos on the average per cluster, the size of these clusters was about one-fourth less than normal. The number of the fresh clusters, which were found to be 4, must thus be reduced to 3. The number of apparently living eggs of this locality therefore was decreased, after Flacherie had worked, to about 7.5 per cent.

Beverly, Mass.

Division Agent, SAUL PHILLIPS; Assistant, W. F. HOLMES.

With the help of the assistant of the division agent two places were selected for the experiments. The place which we will first consider is situated near Hart Street, north of Greenwood Avenue, Beverly Farms. It is an isolated wood of about 1 acre, mainly overgrown with maple about fifty to sixty years of age, and yellow birch, and has dense underbrush. The gypsy moth caterpillars were very numerous here during the summer of 1909, but no disease was noticed among them. A small percentage of egg clusters was killed with creosote during the

winter of 1909-10. A joint estimate of the egg clusters in this locality made with the assistant of the division agent in the spring of 1910 resulted in finding about 500 clusters.

The rearing of caterpillars was undertaken by Mr. Phillips's assistant. On June 20, 1910, he noticed the first dead individuals in the brood. Three days after the receipt of this communication I went to Beverly to inspect the material. Many of the caterpillars had already died from the wilt. This same day (June 25), with the help of the assistant, one part of the material was exposed in the western portion of the locality mentioned. The bag containing the material was fastened about 6 feet from the ground, between limbs with dense foliage. Most of the caterpillars of this locality had at this time just passed the third molt.

After the wilt had operated all through the summer among the caterpillars of this locality, the place was visited again on Sept. 13, 1910, together with Mr. Phillips's assistant. We estimated the number of fresh clusters present to be about 250. The decrease in the size of the clusters compared with those of the previous year was very striking. The examination of the first 5 clusters which were found gave the following result:—

Cluster 1.

Unfertilized eggs, . . .	5	} = 13.60 per cent., or about 13.5 per cent.
Eggs with dead embryos, . .	12	
Eggs apparently alive, . . .	108	
Total, ...	125 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 5.92 per cent., or about 6 per cent.
Eggs with dead embryos, . .	8	
Eggs apparently alive, . . .	159	
Total, ...	169 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	} = 7.37 per cent., or about 7 per cent.
Eggs with dead embryos, . .	6	
Eggs apparently alive, . . .	88	
Total, ...	95 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	} = 5.76 per cent., or about 5.5 per cent.
Eggs with dead embryos, . .	7	
Eggs apparently alive, . . .	131	
Total, ...	139 eggs.	

Cluster 5.

Unfertilized eggs, ...	-	} = 6.45 per cent., or about 6.5 per cent.
Eggs with dead embryos, ...	4	
Eggs apparently alive, ...	58	
Total, ...	62 eggs.	

The average of these 5 clusters gives the following result:—

Dead eggs, ...	9	= 7.63 per cent., or about 7.5 per cent.
Eggs apparently alive, ...	109	= 92.37 per cent., or about 92.5 per cent.
Total, ...	118 eggs.	

Since a normal cluster contains on the average 433 eggs with apparently living embryos, and this place, in which Flacherie had operated, contained only 109 eggs with apparently living embryos on the average per cluster, about 4 clusters were necessary to equal the size of a normal one. The number of fresh clusters, which were estimated to be about 250, thus must be reduced to about 65. The number of apparently living eggs of this locality therefore was decreased, after the wilt had worked, to about 15 per cent.

For the second experiment a small isolated group of oaks, about eighty years of age, was selected. This place is situated near the railroad station, Beverly Farms, between the railroad track and the ocean. The caterpillars of the gypsy moth have always appeared here only in small numbers, and there were hardly more than one dozen clusters in the spring of 1910, according to our estimate. It must be mentioned, especially, that this locality is always exposed to very strong winds.

Flacherie, artificially developed by the assistant of the division agent, was planted among the caterpillars at this place on June 25, 1910, in the same manner as in the first locality. Considering the heavy breeze the material was placed in a wooden box, which was then fastened between limbs; thus the wind was not able to carry off the whole material. Most of the caterpillars of this place were about ready at this time to undergo the third molt.

On Sept. 13, 1910, this locality was visited again. The wilt had done very considerable damage to the caterpillars. Although the place was carefully searched with Mr. Holmes's assistance, we could find but 2 fresh clusters. One of these is especially remarkable, as it lacks completely the protecting covering. The microscopic examination of both clusters gave the following results:—

Cluster 1.

Unfertilized eggs, ...	3	} = 9.17 per cent., or about 9 per cent.
Eggs with dead embryos, ...	8	
Eggs apparently alive, ...	109	= 90.83 per cent., or about 91 per cent.
Total, ...	120 eggs.	

Cluster 2.¹

Unfertilized eggs, ...	38	} = 87.50 per cent., or about 87.5 per cent.
Eggs with dead embryos, ...	116	
Eggs apparently alive, ...	22	= 12.50 per cent., or about 12.5 per cent.
Total, ...	176 eggs.	

The average of these 2 clusters gives the following:—

Dead eggs, ...	83	= 55.70 per cent., or about 55.5 per cent.
Eggs apparently alive, ...	66	= 44.30 per cent., or about 44.5 per cent.
Total, ...	149 eggs.	

Since this place, in which Flacherie had operated, contained only 66 eggs with apparently living embryos on the average per cluster, the size of these clusters was about five-sixths less than normal. The number of fresh clusters, which were found to be 2, thus equal together only one-third of a normal one. The number of apparently living eggs of this locality therefore had decreased, after the wilt had worked, to about 3 per cent.

Cohasset, Mass.

Division Agent, F. A. BATES; Local Superintendent, J. E. GRASSIE.

An island, known as Barron's Island, which is situated southeast of Cohasset in the headpart of Bailey's Creek, was selected for the experiment. This island has an area of about 10 acres, and is densely overgrown, mostly with oaks about twenty-five years of age and with underbrush. The gypsy moth was quite numerous here in 1909, but there was no disease among the caterpillars, according to Mr. Grassie's statement. Our joint estimate of the clusters which were present in the spring of 1910 was about 2,000. No artificial means of destroying the gypsy moth had been undertaken here.

Mr. Grassie, who was intrusted with the breeding of the caterpillars, noticed the wilt in this brood after a feeding of about sixteen days. On June 27, 1910, the caterpillars were inspected, and there were found

¹ Without the protecting cover.

about 70 per cent. individuals already dead from the disease.¹ The same day all the material was exposed, with the assistance of Mr. Grassie, in the western part of the selected place, and about 6 feet from the ground. Most of the caterpillars of this locality were at this time about ready to undergo the fourth molt.

On Sept. 26, 1910, the island was visited again, in company of the local superintendent, to determine in what manner the wilt had operated among the caterpillars. An especially considerable reduction of the number of the fresh egg clusters, compared with those of the previous year, had not occurred. According to our estimate there were about 1,500 fresh clusters. The size of each of these clusters, compared with the clusters found in the spring of 1910, was diminished in such a degree, however, that the clusters were often no larger than a bean. The eggs also were often only covered in part with hair. This, as well as the comparatively small mortality and the smallness of the fresh clusters, may be perhaps a consequence of the late planting of the disease. It is true that a number of caterpillars were killed, but most of them only grew slightly sick, the disease again expressing itself at the time of oviposition. The fresh clusters of this locality were also of an abnormally light yellowish color, which was noticed nowhere else.

The examination of the first 5 clusters found gave the following result:—

Cluster 1.

Unfertilized eggs, . . .	4	} = 6.36 per cent., or about 6 per cent.
Eggs with dead embryos, . .	7	
Eggs apparently alive, . . .	162	
Total, ...	173 eggs.	

Cluster 2.

Unfertilized eggs, . . .	3	} = 23.68 per cent., or about 23.5 per cent.
Eggs with dead embryos, . .	15	
Eggs apparently alive, . . .	58	
Total, ...	76 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	} = 12.28 per cent., or about 12 per cent.
Eggs with dead embryos, . .	6	
Eggs apparently alive, . . .	50	
Total, ...	57 eggs.	

¹ It should be mentioned that Mr. Grassie sent a telephone communication on June 12, 1910, that the wilt had made its appearance among his caterpillars, but by a mistake I did not receive this notice until June 23.

Cluster 4.

Unfertilized eggs, . . .	5	} = 18.31 per cent., or about 18 per cent.
Eggs with dead embryos, . . .	21	
Eggs apparently alive, . . .	116	

Total, ... 142 eggs.

Cluster 5.

Unfertilized eggs, . . .	8	} = 39.15 per cent., or about 39 per cent.
Eggs with dead embryos, . . .	66	
Eggs apparently alive, . . .	115	

Total, ... 189 eggs.

The average of these 5 clusters gives the following result: —

Dead eggs, ...	27	= 21.26 per cent., or about 21 per cent.
Eggs apparently alive, . . .	100	= 78.74 per cent., or about 79 per cent.

Total, ... 127 eggs.

Since this place, in which Flacherie had worked, contained only 100 eggs with apparently living embryos on the average per cluster, more than 4 clusters were necessary to equal a normal cluster. Thus the number of fresh clusters must be reduced to about 370. The number of apparently living eggs of this locality therefore had decreased, after the wilt had operated, to about 18 per cent.

Hingham, Mass.

Division Agent, F. A. BATES; Local Superintendent, A. W. YOUNG.

For the experiment an island of about 1 acre was selected, very densely overgrown with low wood. This island is situated east of Water Street and south of the railroad track in the so-called Millpond. The wood consists mainly of oaks and birches of five to six years of age, and of underbrush. The gypsy moth was quite numerous here in the summer of 1909, but there was no disease among the caterpillars, according to the statements of the division agent and the local superintendent. Several of the clusters were killed with creosote during the winter of 1909-10. The number of the clusters which still remained was estimated by Mr. Young and myself to be about 100.

The breeding of a series of caterpillars was accomplished exactly according to my instructions by the local superintendent, but unfortunately he omitted to send word when the wilt made its appearance, since he had understood that he was to notify me only after all the caterpillars of the brood had died. To convince myself about the con-

dition of the brood, I inspected the caterpillars July 1, 1910, and found that about 60 per cent. of them had succumbed to Flacherie. The first dead caterpillars were noticed by Mr. Young about fifteen days before. On the same day the whole of the material was exposed, with Mr. Young's assistance, in the southwestern part of the island, about 5 feet from the ground. Most of the caterpillars of this locality had at this time just undergone the fourth molt.

On Sept. 26, 1910, this island was visited, again in company with the local superintendent. We could see that the wilt had done very considerable damage to the caterpillars, for there were only a few scattered clusters. According to our estimate there were hardly 15 fresh clusters present; these, moreover, were much smaller in size than those of the previous year. It was also noticed that the clusters were often only partly covered with hair. All these conditions may well be attributed to Flacherie. The almost full-grown caterpillars had contracted the disease, and the females which then emerged from pupæ produced by these caterpillars were unable to oviposit like healthy moths.

The examination of the first 5 clusters found gave the following result:—

Cluster 1.

Unfertilized eggs, . . .	3	} = 9.56 per cent., or about 9.5 per cent.
Eggs with dead embryos, . .	10	
Eggs apparently alive, . .	123	
Total, ...	136 eggs.	

Cluster 2.

Unfertilized eggs, . . .	3	} = 8.82 per cent., or about 9 per cent.
Eggs with dead embryos, . .	12	
Eggs apparently alive, . .	155	
Total, ...	170 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	} = 4.73 per cent., or about 4.5 per cent.
Eggs with dead embryos, . .	7	
Eggs apparently alive, . .	161	
Total, ...	169 eggs.	

Cluster 4.

Unfertilized eggs, . . .	2	} = 10.77 per cent., or about 10.5 per cent.
Eggs with dead embryos, . .	5	
Eggs apparently alive, . .	58	
Total, ...	65 eggs.	

Cluster 5.

Unfertilized eggs, . . .	4	} = 9.22 per cent., or about 9 per cent.
Eggs with dead embryos, . .	9	
Eggs apparently alive, . .	128	= 90.78 per cent., or about 91 per cent.

Total, ... 141 eggs.

The average of these 5 clusters gives the following result:—

Dead eggs, ...	11	= 8.09 per cent., or about 8 per cent.
Eggs apparently alive, . .	125	= 91.91 per cent., or about 92 per cent.

Total, ... 136 eggs.

Since this place, in which Flacherie had operated, contained only 125 eggs with apparently living embryos on the average per cluster, almost 4 clusters were necessary to equal a normal one. The number of the fresh clusters thus must be reduced to about 5. The number of apparently living eggs of this locality therefore had decreased, after the wilt had worked, to about 5 per cent.

Byfield, Mass.

On June 30, 1910, a letter was received from Mr. James O. Hale of Byfield, in which he stated that he had heard of my Flacherie experiments of 1909, and asked for aid in diminishing the gypsy moth caterpillars by using Flacherie. I therefore visited the locality on July 5, 1910, and took with me sick and dead caterpillars which had been raised at Forest Hills. The forest in question is about 4 to 5 acres in size, and consists mainly of oaks of different ages and some underbrush. It is situated on the border between Rowley and Newbury. It is not isolated, but connected with woods which belong to other persons. At the time of my arrival most of the caterpillars had already undergone the fifth molt, so that it seemed questionable whether the disease would be able to show much success this year. The infected material was exposed in the southwestern part of the forest, about 7 feet from the ground. It proved to be impossible to secure a correct estimate of the caterpillars which were present; all that could be stated was that the caterpillars were quite plentiful.

This locality was visited again with Mr. Hale on Sept. 16, 1910, to determine the results. Mr. Hale gave his opinion that there was, at the least, no increase in the number of egg clusters compared with that of the previous year, although there was no visible decrease in the number of the fresh clusters. However, these fresh clusters were considerably smaller than those of the preceding year.

The first 5 clusters collected gave the following counts:—

Cluster 1.

Unfertilized eggs, . . .	2	} = 8.33 per cent., or about 8 per cent.
Eggs with dead embryos, . . .	6	
Eggs apparently alive, . . .	88	= 91.67 per cent., or about 92 per cent.
Total, ...	96	eggs.

Cluster 2.

Unfertilized eggs, . . .	1	} = 3.76 per cent., or about 3.5 per cent.
Eggs with dead embryos, . . .	4	
Eggs apparently alive, . . .	128	= 96.24 per cent., or about 96.5 per cent.
Total, ...	133	eggs.

Cluster 3.

Unfertilized eggs, . . .	1	} = 2.75 per cent., or about 2.5 per cent.
Eggs with dead embryos, . . .	5	
Eggs apparently alive, . . .	212	= 97.25 per cent., or about 97.5 per cent.
Total, ...	218	eggs.

Cluster 4.

Unfertilized eggs, . . .	2	} = 4.72 per cent., or about 4.5 per cent.
Eggs with dead embryos, . . .	4	
Eggs apparently alive, . . .	121	= 95.28 per cent., or about 95.5 per cent.
Total, ...	127	eggs.

Cluster 5.

Unfertilized eggs, . . .	3	} = 5.59 per cent., or about 5.5 per cent.
Eggs with dead embryos, . . .	6	
Eggs apparently alive, . . .	152	= 94.41 per cent., or about 94.5 per cent.
Total, ...	161	eggs.

The average of these 5 clusters gives the following result:—

Dead eggs, ...	7	= 4.76 per cent., or about 4.5 per cent.
Eggs apparently alive, . . .	140	= 95.24 per cent., or about 95.5 per cent.
Total, ...	147	eggs.

We notice that the clusters of this locality in which the wilt had operated are far smaller than normal ones, since about 3 clusters are necessary to equal the size of a normal one. The percentage of dead eggs, however, does not attain that of other localities.

IV. Summary.

The artificially developed Flacherie was planted, after the "dying off" of the breeding material had begun, among the caterpillars of the gypsy moth in the following localities, the de-

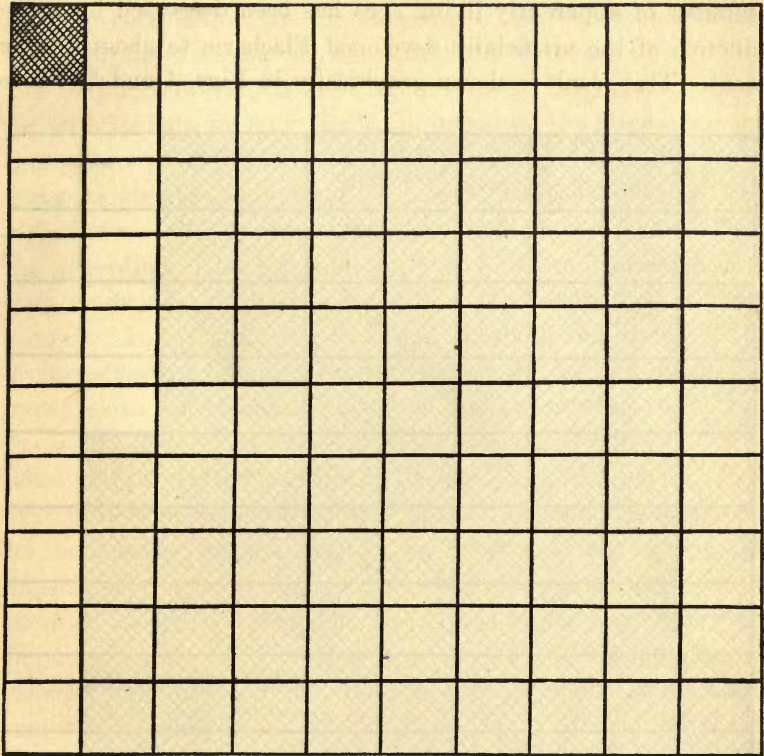


Fig. 4. — Diagram showing percentage of living eggs in healthy colonies.

tails in regard to these experiments being given in the preceding pages. The number of apparently living eggs was reduced to the following percentages: —

	Per Cent.
Concord, Mass. (Brewster's estate), ...	11
Carver, Mass. (southwest of Makepeace's cranberry bog), ...	13
Carver, Mass. (on Wenham Street), ...	45
Boxford, Mass. (near the almshouse), ...	10
Boxford, Mass. (on Highland Street), ...	4
West Bedford, Mass. (Swett's estate), 0 per cent. + 22½ per cent. =	11½
Haverhill, Mass. (west of East Broadway), ...	14½

	Per Cent.
Brockton, Mass. (on Oak Street), ...	7½
Beverly, Mass. (on Hart Street), ...	15
Beverly, Mass. (beside railroad track), ...	3
Cohasset, Mass. (Barron's Island), ...	18
Hingham, Mass. (island in the millpond), ...	5

Taking the average of these results, we see that the total number of apparently living eggs has been decreased by introduction of the artificially developed Flacherie to about 14 per cent. This result is shown graphically in Figs. 4 and 5, where

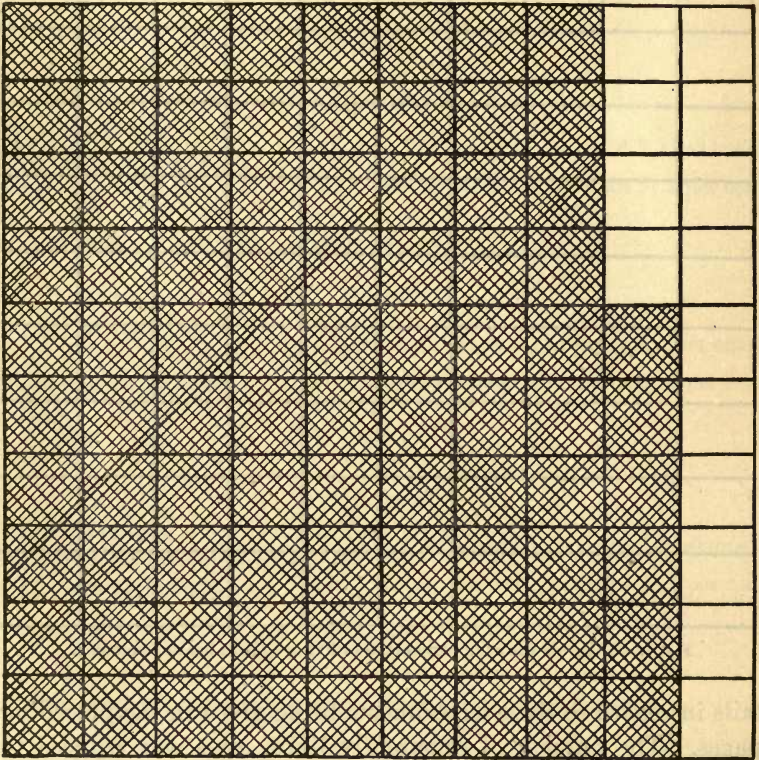


Fig. 5. — Diagram showing average percentage of living eggs after introduction of the disease.

1 per cent. is equal to 1 square, the cross-lined spaces representing the percentage of *dead* eggs.

Only those localities have here been tabulated on which we had complete data from the beginning to the end of the experiment.

V. Final Conclusions.

The foregoing experiments prove conclusively that Flacherie has an injurious influence upon the prosperity of the gypsy moth caterpillars, this influence varying according to the manner and time of the appearance of the disease. There was no difference noticed in the progress of the wilt which broke out naturally and that of the artificially developed Flacherie. The latter, however, is probably the more important factor, for with its help we may be able to introduce the disease among caterpillars of localities in which the wilt, perhaps, would not make its appearance naturally. The infection of a place with *sick* material only seems to be, as regards the "dying off" of the caterpillars, less favorable for the spread of Flacherie than with material which already contains a number of *dead* individuals. In selecting the localities in which the disease is to be introduced, it is unimportant whether the caterpillars of the gypsy moth are present in large or small numbers. It is true the wilt will get a stronger foothold and attain a greater virulence the larger the number of caterpillars. In places, however, which are not badly infested, the disease will also spread to the healthy caterpillars, as was shown by several of the experiments. According to the observations, we are almost inclined to believe that the direction of the wind plays an important rôle in spreading the disease. This opinion is strengthened especially by the observations made in Concord and West Bedford.

Wherever the naturally as well as the artificially developed Flacherie occurs the female caterpillars will always succumb to it more readily than the male. This may perhaps be due to the fact that they require a longer time to mature than the male caterpillars. If, at the flying period of the moth, we visit such a diseased locality, — one in which during the summer the caterpillars were quite plentiful, — we find ourselves surrounded by male moths, which to the superficial observer would indicate that the wilt had caused no considerable diminution. As soon, however, as we begin to search for adult females, we discover that they are present in a decided minority, and

that they are by no means in the same large proportion to the male moths as in localities where the disease has not occurred among the caterpillars. The effective result, then, will be shown at the time of oviposition, in the decrease of the number and size of the fresh clusters, compared with those of the previous year. To be sure, this will not always be the case; for instance, in localities in which *Flacherie* appears very late. However, places infected early enough, always show as a result a diminution in the number of the fresh clusters, sometimes to 100 per cent. The reduced average size of the clusters also has a close connection with the wilt. Heretofore it has often, but erroneously, been supposed that small clusters were deposited by small female moths, which suffered during their caterpillar stages from lack of food. Certainly such cases are not rare, but the origin of small clusters is capable of yet another explanation. For instance, in localities in which there are few gypsy moth caterpillars, and where there is no lack of food, but where the wilt has worked, egg clusters are found which are no larger than a pea or a bean. Such clusters contain from 4 to 12 eggs, with embryos which are usually incompletely or not at all developed. In such localities it may often be recognized, from the volume of the abdomen, even of the freshly emerged female moths, which were little below the normal size, that the body contained only a small number of eggs. Also, in several cases the interior of the body was examined, and then it was found that the cause of the small circumference of the body was that the ovary was small. Females which had already oviposited and died were examined to see whether they contained more eggs in their bodies. Eggs were always found in females that had laid egg clusters which were only partly, or not at all, covered with hair. But there were sometimes found undeposited eggs in females which had completely covered the cluster with their abdominal hairs. All this must be taken in connection with the wilt, for female moths from healthy colonies deposit all the eggs they contain, as long as they are not interrupted at the time of egg laying, and it does not matter whether the individuals are large or small.

The most important point to be noticed is the fact that the

clusters which are found in localities in which Flacherie operates among the caterpillars contain, on the average, a comparatively high percentage of dead eggs. Hence, Flacherie has a direct effect even upon the next generation. If, however, the number and the quality of the eggs in the female adult are affected by the wilt, is it not then possible that the disease goes directly over to the eggs? Certainly we have no direct proof of this at the present time, but we do know that Flacherie can be carried over from the caterpillar to the pupa, and from the pupa to the adult, and we have seen that the eggs in the ovary of females which come from infected colonies are influenced by the disease in regard to their number and vitality. In spite of the many investigations which have been made by celebrated bacteriologists in both the old and the new world, the carriers of the disease have not yet been determined. This shows what a difficult problem science has before it to solve. Although several scientists accept neither the heredity of the disease, nor believe that it can be carried over to the next generation, there are others (Pasteur, Fischer) who believe in its transmissibility. Perhaps the disease is carried over to the following generation through the adult female only, in a similar manner to the pébrine. Perhaps, moreover, the name Flacherie covers several diseases, which, it is true, make their appearance in the same manner in the infected individuals, but nevertheless are specifically distinct. One of these diseases may be restricted, indeed, to caterpillar and pupa only, while the other disease is carried over to the adult, and might possibly be inherited through the female organism by the descendants. It may be possible to throw some light on these complicated questions by breeding experiments, but only the investigations of the bacteriologist and pathologist can secure the final proof. It would be of the highest importance for the economic value of Flacherie if the inheritance of the disease could be definitely proved. If the wilt proves to be the direct cause for the "dying off" of many embryos of eggs from infected localities, death would be caused by the organisms of the disease themselves, and probably not be a result of the weak constitution of the female moth. The still living embryos of the same cluster will

then contain, without doubt, at least partially, the carriers of the disease, which, according to their number and to the constitution of the embryo, will kill, early or late, the larva after it has hatched. Thus Flacherie will be carried again through the whole ontogeny of the descendants of those individuals which were originally infected by the disease. In this case the wilt would be hereditary, and it would have by far the greatest possible economic value and benefit. If, however, the "dying off" of several of the embryos is only a consequence of the weak condition of the female adult, which perhaps was slightly infected during the caterpillar stage, then of course the guaranty for the wilt is not yet given for the next generation. Among the hatching caterpillars there will always be a considerable percentage of weak individuals which thus possess from the beginning the necessary predisposition to the disease. If, then, the climatic conditions develop favorably for the disease, these weak caterpillars will be attacked first by the wilt, but as it increases in virulence it will attack the stronger and healthier individuals. If the climatic conditions are less favorable for the natural appearance of Flacherie, we hope the introduction of the artificially developed Flacherie in the respective localities will transmit the disease to the weak caterpillars. Then the disease will operate as though it had appeared naturally.

The existence of the wilt does not depend upon climatic conditions as soon as the disease is once established. It is true weather conditions will often be of great advantage in spreading the disease, but not likely to be of considerable harm. Hence, Flacherie, even if its nonheredity should be proved, is a factor of great importance to economic entomology. It will be advisable to work with the wilt against the gypsy moth in large wooded areas of all kinds, and it has the great advantage of cheapness, while the spraying with arsenate of lead or with other poisons is expensive. A very good scheme would be to furnish as many trees as possible with rings of tanglefoot in heavily infested forest districts, and not to kill the caterpillars after they are gathered together under the rings, but to assist in this manner the more rapid spread of the wilt, since the sick and weak individuals thus have a greater possibility of coming

in contact with healthy caterpillars. The effect of this method was observed in one case during the summer of 1910. In company with the division agent, Mr. Worthen, I came in touch with a locality in Boxford where gypsy moth caterpillars were gathered together in considerable numbers under tanglefoot rings. It had been decided to kill the caterpillars with burning oil, but I dissuaded the men from doing this by giving as my opinion that the wilt would make its appearance in all probability in a few days. This assumption was right, for there was seen, after three days, the first signs of the disease, which then spread so quickly that in a few more days the caterpillars had succumbed.

Perhaps it might be worth while to work with the wilt in different ways from those in the experiments described. There is, for instance, the recapitulation of the experiments of 1909 on a large scale. Caterpillars which had been killed by Flacherie were mixed with water in different ways, and the mixture was then either sprayed upon trees or was painted as rings around the trunks. One or the other of these methods may prove to be valuable, but the expense will be quite high, while the use of the simple exposure method incurs but small expense. There might be mentioned still another point; Dr. E. Fischer of Zürich, the discoverer of the predisposition of caterpillars towards Flacherie, wrote me some time ago the following directions for developing Flacherie artificially in the field: cut some of the larger roots of a tree that is infested with a sufficient number of caterpillars, water frequently the ground around the cut surfaces and put into the trunk as much water as possible through a hole bored at an angle of about 45° to the base of the tree. By these means the same unhealthy food is produced on the tree as is otherwise obtained by the placing of twigs in water. It is certain that the wilt can be developed artificially in the manner just described, but such an experiment needs constant attention, and trees thus treated are, of course, destroyed.

I doubt whether the gypsy moth will ever become extinct in America, but the wilt will probably produce, first, a considerable reduction of the mass, and then it is to be hoped that the

insect parasites and other natural enemies will contribute in diminishing the pest to a minimum. I am quite convinced that we can apply the wilt in a systematic manner to the benefit of our forests, and that in so doing we shall come considerably nearer to a solution of the problem of destroying the gypsy moth. In wooded areas mainly much more attention should be given in future to the wilt as an aid in combating the insect, while for street trees, garden trees, etc., which are more easily managed, the eggs and caterpillars of the gypsy moth may be removed according to established methods. The wilt should eventually reduce the pest to a condition in which it can be easily kept in check, and prevent serious outbreaks and damage.

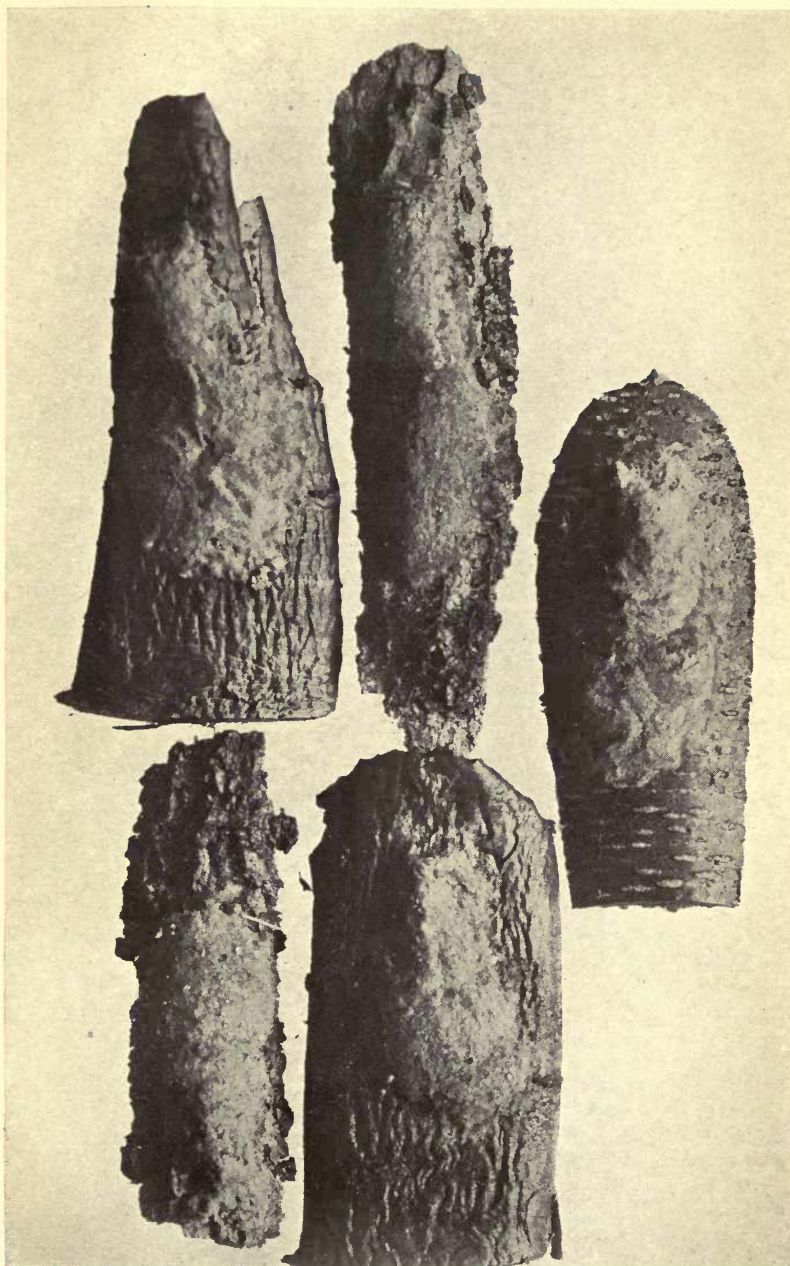


PLATE I. — Egg clusters from a healthy colony.

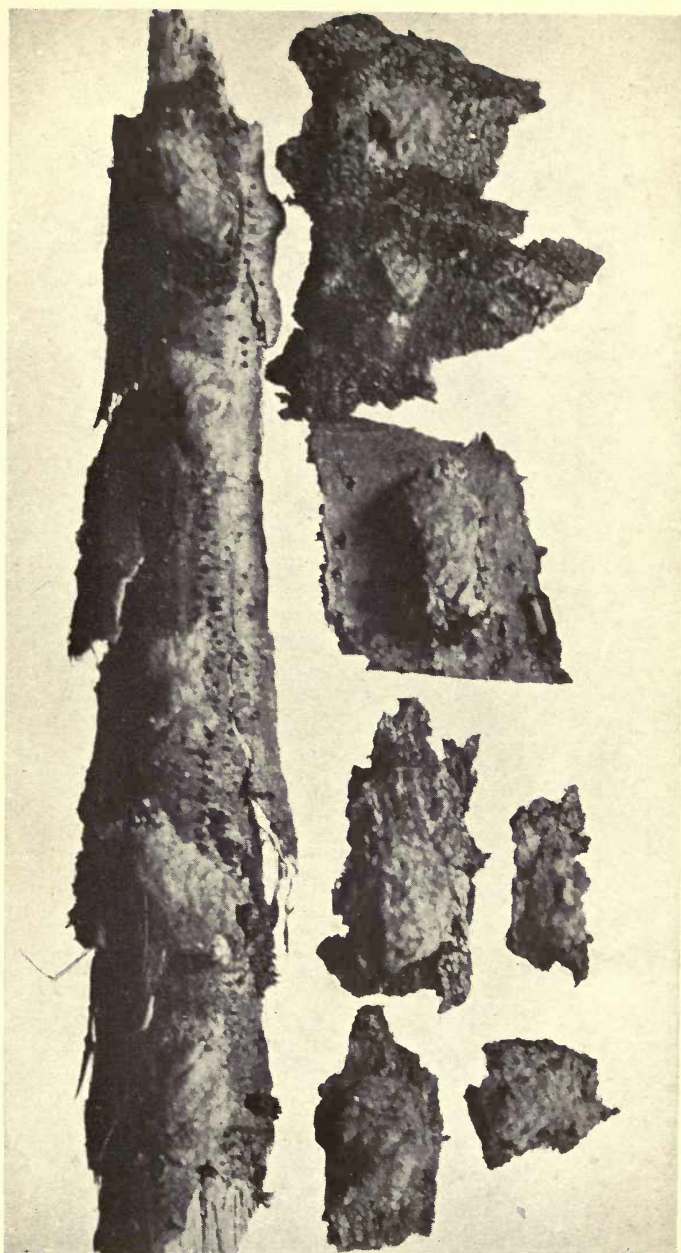


PLATE II.—Egg clusters from a colony where disease was introduced.

